FRONTISPIECE

The normal infant at eight months.

PRACTICAL INFANT FEEDING

By

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To

My Friend and Chief

John Lovett Morse, A. M., M. D.

A Truly Great Practical Clinician

and Teacher

PREFACE

I HAVE tried to write a book on infant feeding which will be practical without being superficial, scientific without being tiresome. Its paramount purpose is to attempt to help the practitioner not only to treat but to *understand* feeding cases as they occur in his daily practice. It is absolutely essential, and not too much to ask, for the general practitioner, or anyone else who is feeding babies, to have a considerable knowledge of the chemistry of metabolism in normal and abnormal babies before they can feed them intelligently, and before they can be said to have a satisfactory working knowledge of infant feeding. This is what too many practitioners lack. They must know the processes that are going on in the digestive tract, and must understand what the different food elements do under various conditions, but so many conflicting views are held by various investigators in this country and abroad that it would be of little value in a text-book to attempt to give a review of the literature which forms the corner-stone of scientific infant feeding without setting any definite interpretation upon it. To my mind a text-book of infant feeding should consist of a clear presentation of what is generally believed on the subject, seen and interpreted through the eyes of the author, and largely supplemented by his own practical experience. It should serve at the same time as a working guide for the general man and as a reference book for the pediatrist.

I have tried in this book to effect a common-sense combination of science and practice, to *apply* scientific principles to practice as much as possible, to go into a good deal of detail concerning certain scientific investigations which are of practical importance, and to omit others which are not. It has not been my purpose to follow any one "school" of infant feeding,

but rather to amalgamate the best points taught in this country and abroad into what I hope is a homogeneous whole.

It is desirable, of course, to make any subject as simple and as easily understandable as possible, and infant feeding need not be made complicated, but, on the other hand, any presentation which does not explain underlying processes and the basis of symptoms is not enough for the *thinking* practitioner of today. As I heard an eminent Philadelphia pediatrist say not long ago, there is at present a tendency to try to make infant feeding so easy for the physician that there is a chance of forgetting whether or not the methods used may be suitable for the baby.

The general standard of infant feeding in America has, however, improved greatly in the last ten years owing to the increased interest that general practitioners have taken in it, which is shown by the continually increasing numbers coming for instruction to the large post-graduate schools, such as the Harvard Graduate School of Medicine and the New York Post-Graduate School.

To such men as this I respectfully offer this book, and sincerely hope that they may find it of value and interest.

I wish especially to thank Dr. W. W. Howell for so kindly consenting to write the chapter on Premature Infants; Dr. R. W. Lovett and other members of the staff for permitting me to use several pictures and Roentgen-ray plates taken from their cases in the Children's Hospital; Mr. J. V. Footman for kindly making the prints and taking many pictures, and the publishers for their many courtesies.

Lewis Webb Hill.

483 Beacon Street,
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CHAPTER I

THE PHYSIOLOGY AND PATHOLOGY OF DIGESTION AND OF NUTRITION

THE NEWBORN INFANT

Von Reuss[1] (Vienna) gives the average weight of the normal full term infant as 7 lbs. 2 oz. for boys and 6 lbs. 9½ oz. for girls. Ramsey and Alley[2] (Minnesota) in a series of 300 newborn babies found that the average weight was 7½ lbs. for boys and 7 lbs. 3 oz. for girls. In Curry's[3] series of 521 cases (San Francisco) the average was 7 lbs. 3 oz. for females and 7 lbs. 11 oz. for males. Hecker of Munich (quoted by Von Reuss) in a large series of cases observed the following weights:

5 lbs.	8 oz.	(2500–2999 gm.),	25.8	per cent. of cases
6 lbs.	8 oz.	(3000–3499 gm.),	44.4	" " "
7 lbs.	11 oz.	(3500–3999 gm.),	24.7	" " "
8 lbs.	12 oz.	(4000–4499 gm.),	4.6	" " "
9 lbs.	15 oz.	(4500–4999 gm.),	0.48	" " "
11 lbs.		(5000–5499 gm.),	0.02	" " "

Every baby loses normally a certain amount of weight during the first few days of life. This loss, according to Talbot,[4] is of two kinds: (1) mechanical, (2) physiologic. The mechanical loss is due to the passage of urine and meconium (70–90 gm.),

[1] Die Krankheiten des Neugeboren, Berlin, 1914.

[2] Amer. Jour. Dis. Chil., vol. 15, 1918.

[3] Quoted by Yerington, Jour. Amer. Med. Assoc., vol. 71, September 28, 1918.

[4] Amer. Jour. Dis. Chil., vol. 13, 1917.

the loss from the removal of vernix caseosa and other secretions, and possibly sometimes the vomiting of allantoic fluid, which the baby may have swallowed before birth. The "physiologic" loss of weight is that caused by actual oxidation of body substance. For a few days, during the colostrum period, the baby is in a state of partial starvation, and the energy to supply his fuel needs has to come from oxidation of his body substance instead of from ingested food. The glycogen of the liver and tissues is first used, and when this is exhausted the body fat is burned. "Infants without a good layer of body fat should receive food at the earliest possible moment" (Talbot).

The colostrum period usually lasts about three days, and it is not until about the fourth day in most cases that the milk secretion is established. Colostrum is a concentrated food, but there is very little of it. According to the analyses of Camerer and Soldner, very early colostrum contains fat 4.08 per cent., lactose 4.09 per cent., protein 5.80 per cent., ash 0.48 per cent.; according to those of Bailey and Murlin,[1] fat 2.9 per cent., lactose 7.1 per cent., protein 2.3 per cent. The amount of colostrum is usually estimated at about 20 c.c. on the first day, increasing somewhat on the second and third days.

Loss of water from the body is also of considerable importance, according to some authorities the most important factor in causing loss of weight. Birk and Edelstein[2] found that the amount of water lost from the infant's body was 28.12 gm. per kilo for the first twelve hours, and 40.74 gm. and 53.6 gm. respectively for the next two twenty-four-hour periods. Von Reuss gave a considerable amount of water from the first day to a series of newborns, and noticed that there was much less loss of weight than in those babies to whom no water was given. The loss of weight continues for about three days, and on the third or fourth day the minimum is reached. The loss usually varies between 150 and 300 gm. (5–10 oz.), but occasionally may reach 400 to 500 gm. in babies who are apparently normal.

[1] Amer. Jour. Obstet., vol. 1, 1915.
[2] Monatschr. f. Kinderh., vol. 60, 1910.

If the breast milk is late in coming in, or if it is lacking in quality or quantity, the initial loss of weight may be considerably more. The loss is proportional to the absolute body weight, and is usually about 6 to 9 per cent. of it. There is less likely to be a large loss of weight if the baby is nursed on the first day, and at frequent intervals; babies nursed or fed artifically at four-hour intervals almost always lose more weight than those fed at 2- or 2½-hour intervals. According to Benestad[1] babies suffer a greater loss of weight, both relatively and absolutely, the greater the birth weight is. Most of the loss occurs during the first twenty-four hours, and according to various authors as much as 125 gm. may be lost in this time. Most authorities are agreed that nothing can stop the initial loss of weight, but Schick[2] in 9 cases was able to prevent it by frequent forced feedings with a mixture of colostrum and breast milk. An excessive loss can be practically always prevented by proper feeding. According to Camerer the birth weight is regained by the eighth or tenth day, while according to Ramsey and Alley only about 25 per cent. of all cases regain the birth weight by the tenth day. Bergman,[3] in a series of 1000 hospital cases, found that 11.4 per cent. regained their birth weight by the tenth day, 21.7 per cent. by the fourteenth day, and 24.1 per cent. had not regained it by the twenty-first day. All these babies were fed at four-hour intervals, however, and, moreover, were hospital cases. It is hardly fair, then, to accept these figures as a standard, and in most cases the average breast-fed baby in a private house, looked after carefully and fed at 2½- or 3-hour intervals will regain the birth weight by the fourteenth or fifteenth day. In the case of bottle-fed babies, however, the situation is far different, and many normal babies who have had to be fed entirely on the bottle from the day of birth may fail to regain their birth weights before the end of the third or fourth week.

Body Temperature.—At birth the body temperature is

[1] Jahrhb. f. Kinderh., vol. 80, 1914.
[2] Ztschr. f. Kinderh., vol. 13, 1916.
[3] Ibid., March, 1916.

relatively high (99.8°-100.8° F.), but during the first few hours of life a newborn baby loses a considerable amount of heat, and it is not unusual to record rectal temperatures of 95° F. in healthy full-term infants a few hours after birth. If the baby is kept warm the temperature soon comes up to normal, however. The first bath usually depresses the temperature from 1 to 1½ degrees, and in the first week of life the daily variations are much greater than in older children (1° to 2° F.) (Von Reuss). The heat-regulating mechanism during the newborn period is very unstable, and newborn babies are likely to react differently than older babies to infection. Severe infections, such as erysipelas, may in some cases cause only a slight rise of temperature, while in other cases the temperature may be very high from relatively slight causes.

Transitory Fever of the Newborn.—Not a few normal infants show a rise of temperature to 101° or 102° F., most commonly on the third, fourth, or fifth days. In many cases it is not accompanied by symptoms, while in others the baby may be restless and irritable, with mild toxic symptoms. Marked toxic symptoms are unusual, but may occur. The temperature usually lasts from twenty-four to forty-eight hours, and then rapidly subsides. It is difficult to estimate how frequently this transitory fever occurs, as it is undoubtedly often overlooked. Crandall[1] found at the Sloane Maternity Hospital in New York that it occurred in 135 of 500 consecutive newborns, a rather high percentage, while at the Nursery and Child's Hospital only 20 babies out of 200 showed it. Heimann[2] found that if the baby was not put to the breast until twenty-four hours after delivery, from 2.3 to 4.2 per cent. had transitory fever, while if the nursing was begun 12 hours after delivery only 0.6 to 1.3 per cent. showed it. Von Jaschke[3] in 1000 newborns found only 31 with transitory fever. The etiology of the condition is not well understood. It has been usually called "inani-

[1] Arch. Ped., vol. 16, p. 174, 1899.
[2] Monatschr. f. Geburtsh. u. Gynäkol., Bd. 51, 1920.
[3] Ztschr. f. Geburtsh. u. Gynäkol., 78, 119, 1915.

tion" or "exsiccation" fever, and has been supposed to be due to the desiccation of the tissues during the first few days of the newborn period, when but little fluid has been taken. It has also been supposed to occur especially in babies who lose an excessive amount of weight, which is somewhat borne out by the fact that it is seen most commonly on the third to fifth day, when the weight has usually reached its lowest point. These views have, however, been recently disproved by Grulee and Bonar,[1] who found that there was no regular relationship between the occurrence of fever and the amount of fluid taken, or the weight loss. They believe that it is best explained by the absorption of some protein products, bacterial or otherwise, from the intestine, probably from putrefaction of the meconium, which is relatively high in protein and low in sugar. As soon as the breast milk comes in, and the high protein meconium is replaced by the high lactose breast milk, putrefaction stops, and the fever subsides. It is probable, however, that many factors are operative, and an excellent summary of them is given by Von Reuss[2]:

"The replacement of meconium flora by milk flora in the intestine; the irritant effect of bacterial products of decomposition or toxins, and of nutritive ingredients on the intestinal cells, the presence of products of the breaking down of tissue such as occurs during the first days of life; the deficiency of water, due partly to an inadequate external supply of fluid, and partly to internal causes, and the resulting concentration of tissue fluids and restriction of diuresis; and finally, the backwardness of the mechanism of heat regulation."

Diagnosis.—This is not ordinarily difficult, but it must be remembered that there are other causes of temperature in the first few days. *Sepsis* does not ordinarily have to be considered, as it occurs very rarely before the fifth day. "Transitory" fever practically always occurs *before* the fifth day. Furthermore, if sepsis is present, the focus can be found. Naso-

[1] Amer. Jour. Dis. Chil., vol. 22, No. 1, July, 1921.

[2] Diseases of the Newborn, London, 1920, p. 475.

pharyngitis, otitis media, and pyelitis occur occasionally in newborns, and must be ruled out. I have recently seen a baby of three days with an otitis media which gave rise to a high temperature, and subsided as soon as the ear drum was incised, and a considerable amount of bloody serum was evacuated. The ears should always, therefore, be examined in any newborn baby with an unexplained fever. With otitis media the baby is usually a good deal sicker than is the case with "transitory" fever.

Pyelitis is very rare in the newborn, but has been reported. The diagnosis is made by an examination of a catheter specimen of the urine.

Treatment.—One-half teaspoonful of castor oil should be given at once, and fluid and food forced. If the breast milk is late in coming in, as it very frequently is, a few ounces of breast milk should be secured from some other woman, and should be given in small, frequent feedings. If breast milk is not available, a weak cow's milk modification is given, with a very low fat and protein and relatively high sugar. Water should be given frequently in as large amounts as possible between the feedings. The condition is not a dangerous one, and the fever practically always subsides in a day or two, without further symptoms. Its chief importance in most cases is that a good deal of alarm is unnecessarily experienced. In a few cases, however, toxic symptoms are marked, but usually subside after catharsis and free fluid and sugar intake.

THE PHYSIOLOGY OF THE DIGESTIVE TRACT

The Mouth.—Mouth digestion is relatively unimportant until the baby possesses ten or twelve teeth. Even then it is not as important as in adults, as babies ordinarily chew very little. The habit that many babies have of holding food in their mouths for some time before swallowing probably aids somewhat in the digestion of the starches, even if only a few teeth are present. The quantity of saliva in the first week of life is very small, but it has been shown to contain ptyalin. When

the teeth begin to appear the secretion of saliva becomes more abundant. The weight of the salivary glands at three months is double that at birth, and at a year is quadrupled.[1]

The **stomach** of the infant is placed more vertically than that of the adult, which accounts partly for the ease with which babies regurgitate. The pylorus lies slightly to the right of the midline between the umbilicus and the xiphoid. The average anatomic capacity of the stomach in newborn babies, according to Scammon and Doyle,[2] is 25 c.c. The anatomic capacity, or size of the stomach, is however, not a good index of the physiologic capacity, or amount of food that may be taken at one time, as a good part of it passes out through the pylorus before the last part has entered the stomach. The stomach increases rapidly in size during the first few days of life. According to Scammon and Doyle, the following average amounts of breast milk were taken at each feeding by a large series of normal breast-fed babies during the first ten days:

Day.	Amount taken at each feeding.
1	7 c.c.
2	13 "
3	27 "
4	46 "
5	57 "
6	64 "
7	68 "
8	71 "
9	76 "
10	81 "

The table below, showing the size of the stomach at different ages, is from Pfaundler and Schlossmann:

Size of the Stomach at Various Ages

1 month,	3 oz.	4 months,	4 oz.	7 months,	$7\frac{1}{3}$ oz.
2 months,	$3\frac{1}{3}$ "	5 "	6 "	8 "	$8\frac{1}{3}$ "
3 "	$3\frac{1}{2}$ "	6 "	$6\frac{2}{3}$ "	9 "	9 "
				1 year,	$9\frac{2}{3}$ "

[1] Gundobin, Die Besonderheiten des Kindesalters, Berlin, 1912.
[2] Amer. Jour. Dis. Chil., vol. 20, No. 6, 1920.

Secretions of the Stomach.—The stomach secretes four substances of importance: pepsin, rennin, hydrochloric acid, and a fat-splitting enzyme. In breast-fed babies free HCl is found about 2 hours after the meal in a concentration of about 0.10 per cent. In bottle-fed babies it is found later, or not at all, on account of the greater powers of the cow's milk (casein) to combine with the acid. Inasmuch as free hydrochloric acid is a strong antiseptic agent, and undoubtedly destroys a good many of the bacteria which are introduced into the stomach, the stomach contents of a bottle-fed baby are less antiseptic than those of a breast-fed baby. This may be of considerable practical importance in causing digestive disturbances by allowing the bacteria which have not been killed off to attack the food in the digestive tract. Stomach digestion proceeds somewhat as follows (Tobler): Soon after the milk enters the stomach it is coagulated by the rennin. The curd and whey are separated, and in the first part of the digestive period the liquid portion of the chyme is passed into the duodenum. Most of the casein and fat remain behind in the stomach and is slowly digested and liquefied by pepsin and hydrochloric acid digestion. The products of this (protein) digestion are albumoses and peptones. The fat also undergoes a certain amount of digestion by the action of the gastric lipose. Sugar is not acted upon, and most of it leaves the stomach in the whey. It is probable that even in babies with severe digestive or nutritional disturbance there is little or no deficiency of the gastric digestive ferments. There is very little absorption of either water or food material from the stomach.

Motility and Emptying Time of the Stomach.—Peristalsis begins soon after taking food. The peristalsis of the stomach mixes the food thoroughly with the gastric juice, in the pyloric portion especially. At certain intervals the pyloric sphincter relaxes and the contraction wave squeezes some of the fluid into the duodenum (Howell[1]). According to Maynard Ladd,[2] who

[1] Text-Book of Physiology, Philadelphia, 1915.
[2] Amer. Jour. Dis. Chil., May, 1913, vol. 5.

has extensively studied gastric motility in infants by means of the Roentgen ray, "There is a curious lack of peristalsis to be seen in infants' stomachs as compared with adults.

"The stomach empties itself of the greater part of its contents in from one to two and one-half hours. This time varies considerably, however, in different babies. After the greater part of the stomach contents has passed into the small intestine, a considerable residue remains, which is emptied very slowly, after remaining for from four to seven hours, in both bottle- and breast-fed babies."

In most cases Ladd found that the stomach was nearly empty after two hours. A new feeding tends to stimulate peristalsis and to push out ahead of it the residue of the previous feeding.

There is a very great difference in the emptying time in different babies, as Ladd found that with 3 infants of the same age on the same formula, $2\frac{1}{2}$, $3\frac{3}{4}$, and $4\frac{1}{2}$ hours were required to empty their respective stomachs. The sort of food taken is, of course, important, and one infant in Ladd's series required on different occasions, with different formulas, $2\frac{1}{2}$, $4\frac{1}{2}$, 6, and $7\frac{1}{2}$ hours to completely empty his stomach. Sugar, either lactose or maltose, up to 7 per cent. has apparently no influence upon gastric motility. If the protein in the food is kept low even the fat fails to show any constant tendency to prolong the emptying time, and if the percentage of fat influences the motility at all the effect is not striking.[1] Casein is the most important food element concerned in the emptying time; its effect in this respect depends considerably upon the form in which it is given. Protein in high percentage without the addition of alkali retards the emptying time; if it is converted into a non-coagulable form by the addition of alkali, the stomach empties much more quickly. Sodium citrate does not influence the emptying time as much as do soda bicarbonate or lime-water.

The **duodenum** secretes a not inconsiderable amount of alkaline juice, alkaline on account of its carbonate content.

[1] According to Tobler, fat delays the emptying time.

This juice is not especially important in digestion (Burton-Opitz[1]). It contains invertin, which inverts cane-sugar, and also erepsin. Its chief importance is that it contains enterokinase, a substance which has the power of activating the pancreatic juice so that it is more efficient in the digestion of protein.

The Intestines.—Both the small and large intestines are relatively longer in the infant than in the adult, which is probably necessary on account of the relatively large amount of food taken by the infant. The small intestine secretes large quantities of alkaline juice, the succus entericus. It is light yellow in color, and its chief function is to break down carbohydrates, specially sugar, by the two sugar-splitting ferments which it contains, maltase and invertase, whose functions are to change disaccharids to monosaccharids. It also contains erepsin, which converts proteoses to polypeptids and amino-acids.

The most import phases in the digestion of milk are carried on in the upper portion of the small intestine by the pancreatic juice and the succus entericus. The digestion of the various food elements are very delicately adjusted processes, which need a certain optimum reaction (not too acid or alkaline) in order to proceed satisfactorily. If there is an excessively acid or alkaline reaction in the small intestine where the digestion and absorption of food is taking place, these processes cannot proceed correctly. The ordinary cause of excessively alkaline or acid reactions in the small intestine is the action of bacteria on foods there, and it can therefore be easily seen how important it is for the small intestine to be relatively free from bacteria.

In the large intestine there is practically no digestion carried on, and probably little absorption, except of water. Nearly all the food that is going to be absorbed is absorbed before the ileocecal valve is reached. The large intestine is swarming with bacteria of many kinds, which live on the undigested or unabsorbed food residue entering from the small intestine. If this residue is not too great in amount, excessive fermentation or

[1] Text-Book of Physiology.

putrefaction will not take place; if it is large in amount, one or the other of these processes becomes excessive, and diarrhea results.

The **liver** in the infant is much larger in relation to the rest of the body than it is in the adult. In a newborn baby the liver is 4.33 per cent. of the body weight, in an adult, 2.85 per cent.

The functions of the liver are to change starches, sugars, protein, and possibly fat into glycogen, to produce bile, and to neutralize and destroy poisons arising from the intestines. The liver is frequently enlarged in nutritional disorders, especially those arising from overfeeding with carbohydrate.

The Bile.—Fresh bile is reddish-brown in color. Upon oxidation it changes to green, or upon reduction it may be colorless. Bile is what gives the color to the stools, and this color depends upon whether oxidation or reduction processes are taking place in the intestine. In the putrefaction that occurs when soap stools are produced the bile undergoes reduction and assumes a colorless form, so that the stools are nearly white. When sugar is fermenting, however, oxidation is taking place, and bilirubin is changed to biliverdin, which gives the characteristic green color to the stools.

The chief function of bile is to aid in the digestion and absorption of fat. In the presence of bile the steapsin of the pancreatic juice is much more active in splitting fats than without it. Fat digestion is best in a nearly alkaline solution, and very poor in a strongly alkaline or especially in a strongly acid solution. Bile in a strongly acid solution is easily decomposed and rendered inefficient. It is able under the right conditions to dissolve large amounts of fatty acids, and also probably aids in absorption by emulsifying soaps.

The Pancreas.—The juices of the pancreas are the most important and powerful of all the digestive juices. The pancreas has about the same significance in the infant as in the adult. It produces a strongly alkaline secretion in large amounts, which contains trypsin, amylopsin, and steapsin. These ferments digest protein, starch, and fat respectively, and are all present

in the pancreas at birth. Pancreatic digestion cannot go on in a strongly acid medium.

Summary.—From a practical point of view we are chiefly interested to know what part if any a lack of digestive ferments plays in the various digestive and nutritional disturbances of babies. The evidence here is conflicting, some investigators have found that certain ferments, particularly the fat-splitting ferment of the pancreas, are present in very small quantity or are lacking entirely in severe nutritional disorders, such as marasmus. It is probable, however, that this deficiency is not the cause but the result of the condition, and most investigators have found that in most cases of digestive disturbances in babies a deficiency of the digestive ferments plays little if any part. Thus the artificial digestants are of small practical value in the treatment of digestive disorders in infants.

THE BACTERIOLOGY OF THE DIGESTIVE TRACT AND THE RELATION OF BACTERIA TO FOOD

Importance.—The bacteriology of the gastro-intestinal tract is intimately concerned with problems of practical infant feeding, as there is normally always a slight bacterial decomposition of food going on in the lower portions of the bowel. If this decomposition becomes excessive, owing to poor digestion of food or overfeeding, large amounts of irritating substances are formed, which immediately get the baby into trouble, evidenced especially by looseness of the bowel movements.

The intestinal bacteria act on the host not directly, but through the intermediate agency of food, and its decomposition products. They are not ordinarily true parasites, but saprophytes; they live not on the tissue of the gastro-intestinal tract, but on the food within it.

The intestinal contents at birth are sterile, and the first specimens of meconium passed usually fail to show bacteria. Infection takes place, in all probability, mostly through the mouth, but also probably partly through the anus, so that bacteria are ordinarily found in the meconium twenty-four

hours after birth.[1] "As a rule the proliferation of these first infecting organisms is limited, partly because the intestinal contents at this time are inadequate to support a large bacterial population, partly because a majority of the bacteria are unable to accommodate themselves to gastro-intestinal conditions.

"About the third day postpartum the alimentary canal of the infant becomes permeated with breast milk in place of the colostrum, and a marked change is discernible in the intestinal flora at this time. The heterogeneous, irregularly staining microbes disappear to a remarkable degree, and coincidently large numbers of long, slender, Gram-staining bacilli appear. A majority of these belong to the group of Bacillus bifidus, and they usually persist in dominant numbers during the nursing period."

The infecting bacteria come partly from the air, partly from the bath-water, or perhaps from the vagina of the mother. The initial bacterial flora is independent of the sort of food that there is in the intestine, but after the first two or three days is dependent upon the type of food that is present. According to Czerny and Keller it is not advisable to give sugar-water during the first day or two before the breast milk comes in, as is commonly done, because fermentation might be started which would be injurious to the child.

"If we feed the newborn in the first few days with foreign substances, we must remember that we may hinder or disturb the normal processes of invasion. It is best to give nothing but sterile water or water plus saccharin during the first twenty-four hours to a newborn baby."[2]

Bacteriology of the Stomach.—Many bacteria enter the stomach in the food of bottle-fed babies, but the gastric juice possesses strong antiseptic powers, and destroys a great many of them. The stomach, therefore, acts as a protection to the rest of the gastro-intestinal tract in this respect, and is on

[1] Kendall, Amer. Jour. Med. Sci., No. 2, vol. clvi, August 7, 1918.

[2] Czerny and Keller, Des Kindes Ernährung, etc., 1906.

account of its antiseptic power relatively free from bacteria in comparison with the lower portions of the digestive tract. From a practical point of view bacterial decomposition of the food in the stomach is not of much importance, except possibly in conditions of stasis, such as would exist with pyloric stenosis.

Bacteriology of the Small Intestine.—The small intestine, especially in the upper portions, is also relatively free from bacteria. The necessity of this is apparent, for if many bacteria were present and were continually attacking the food while digestion and absorption were taking place no proper digestion could occur.

"The bacterial poverty of the upper part of the intestine, which, as long as physiologic conditions are maintained in the intestine, is reasonably constant, and guarantees a normal digestion process by the ferments alone without the interference of bacteria and bacterial decomposition products."[1]

The intestinal secretions (bile, pancreatic juice, succus entericus) have little if any bactericidal power, so the small intestine depends very largely upon the bactericidal power of the stomach to keep it from being overrun with bacteria. The epithelial cells of the small intestine, when functionally and anatomically intact, also probably possess a certain degree of antibacterial power, and when these are injured in any way by inflammatory processes, or their function is depressed by chemical agencies, a marked overgrowth of bacteria may take place. Rolly and Leibermeister[2] were able to increase the bacterial content of the small intestine by feeding large doses of soda bicarbonate or chlorid of iron. It has also been thought that the concentrated salt content of cow's milk may depress the antibacterial powers of the epithelial cells of the small intestine in such a way as to allow a greatly increased bacterial population to be present there, with a consequent decomposition of any food present. This has been given great importance by the Finkelstein school

[1] Tobler and Bessau, Allegemeine Pathologische Physiologie der Ernährung, etc., Wiesbaden, 1914.

[2] Cited by Tobler, p. 75.

especially. In the lower part of the ileum bacteria begin to increase in numbers, and conditions to approach those of the large intestine.

Bacteriology of the Large Intestine.—The large intestine is swarming with bacteria of many varieties, maintained there by the food residue which comes from above. There are three probable reasons why the large intestine should be so rich in bacteria:

The antiseptic action of the gastric juice does not reach so far down.

Peristalsis is much slower than in the small intestine, and food, therefore, stays there a longer time.

The epithelial cells of the large intestine possess no antibacterial power.

Under normal conditions the amount of food present in the large intestine is not sufficient for enough decomposition to take place to cause trouble. Under abnormal conditions, when too large a residue of undigested food is present, the bacterial content may be enormously increased, and food decomposition, with its resulting irritating products, excessive.

Kinds of Bacteria Present.—The flora of the breast-fed baby's intestine is remarkably uniform, and consists largely of the Bacillus bifidus, an organism living chiefly upon sugar, and forming lactic acid from it. The colon bacillus and the Bacillus lactis aërogenes are also numerous, and many other less important forms are present in smaller numbers. The fecal flora of the breast-fed baby is especially characterized by the fact that it is Gram-positive. In the bottle-fed baby conditions are not so uniform. "The changes are, generally speaking, a substitution of Gram-negatively staining bacteria of the colon type for a considerable proportion of the Gram-positively staining organisms so distinctive of the flora of the normal nursling, as well as the appearance of large bacilli (many of the spore-forming), cocci, and variable numbers of microbes that vary from time to time and from individual to individual."[1]

[1] Kendall, Amer. Jour. Med. Sci., vol. clvi, No. 2, 1918.

Dependence of the Type of Bacteria on the Food Supply.—Escherich was the first to show (1886) that the type of bacterial flora in the intestine is dependent upon the sort of food ingested and that changes in it can be produced at will by alterations in the food. As the food is changed those organisms which cannot adapt themselves to the new conditions die out, and others, of more adaptable type, take their place (Kendall). Escherich divided the intestinal bacteria into two broad groups, the putrefactive, which live upon protein food, and the fermentative, which live upon carbohydrate.[1] If a food containing large amounts of protein and relatively small amounts of carbohydrate is ingested, the putrefactive bacteria will flourish, and the fermentative tend to die out; if a high carbohydrate food is offered, the reverse is true. The reason why the flora of the breast-fed baby's intestine is so uniform is that his food is uniform; a high carbohydrate, low protein food, which encourages the growth of the characteristic bifidus flora (fermentative) and inhibits putrefaction. In the bottle-fed baby the conditions of food-supply are not so uniform, his food may be rich or poor in carbohydrate or protein, as the case may be, and his intestinal flora may change from time to time on account of the changes made in the food. In general, the feeding of cow's milk calls forth a putrefactive flora on account of the relatively large amount of casein it contains. These truths are of great practical importance, and one uses them every day in his clinical feeding work.

FERMENTATION AND PUTREFACTION

In the breast-fed baby's large intestine conditions of fermentation normally obtain, owing to the high lactose content and relatively low casein content of breast milk, which maintains a fermentative flora and inhibits putrefaction. This gives rise to an acid reaction of the large intestine, as the products formed from fermentation of sugar are acid in character (largely lactic acid in the breast-fed baby).

In the bottle-fed baby the question of whether fermentation

[1] Some types may live upon either.

or putrefaction will predominate depends upon the character of the food; if large amounts of sugar are given, with little protein, fermentation results, with an acid large intestine; if large amounts of protein with little fermentable carbohydrate are given, putrefaction, with an alkaline reaction results, the end-products of protein putrefaction being alkaline in character. Within certain limits these two processes can take place together, and ordinarily do so, but if one becomes markedly predominant, the other recedes. Under normal conditions a slight putrefaction exists in the large intestine of a bottle-fed baby; if more protein and less carbohydrate is fed, this becomes increased. Normally, in the bottle fed, neither putrefaction nor fermentation should be too markedly predominant; if either process becomes so, trouble results due to the consequent overgrowth of bacteria and the irritating end-products formed. A sugar which is completely absorbed in the small intestine has little influence on fermentative processes in the large intestine, but if it is absorbed with difficulty, and a considerable portion of it finds its way into the large intestine, it acts as a food for the ever-ready fermentative bacteria, and conditions of fermentation quickly result. As long as neither fermentation nor putrefaction is excessive, the reaction of the large intestine is either neutral, weakly alkaline, or weakly acid. If excessive fermentation or putrefaction results the reaction becomes too strong one way or the other, and diarrhea is caused by the irritant effect upon the intestinal mucosa of either the strongly acid or alkaline end-products. Under normal conditions the fermentation or putrefaction of food takes place in the large intestine only. Under abnormal conditions it may take place in the small bowel as well, these abnormal conditions being brought about usually by one of three agencies, or a combination of the three:

1. The introduction of so many bacteria in spoiled milk that too many of them get through the stomach into the intestine in a viable condition.

2. A depression of the antibacterial power of the epithelial cells of the small intestine from inflammation, from excessive

external temperature, debilitated condition of the baby, or other agencies.

3. The swallowing of infected mucus from rhinitis, bronchitis, or any upper respiratory infection.

Types of Bacteria which Produce Fermentation or Putrefaction.—As fermenting organisms the following are the most important: the enterococcus, which is similar to the ordinary Streptococcus lacticus, the Bacillus bifidus and acidophilus, the coli aërogenes group, and the Bacillus aërogenes capsulatus, or "gas bacillus" (in pathologic cases especially). Some of these organisms cause lactic acid fermentation, some acetic or butyric acid fermentation. The colon, the butyric acid bacillus, and proteolytic bacteria are the most important putrefying organisms. The colon bacillus may attack either carbohydrate or protein, but if carbohydrate is present, grows upon this in preference. When the colon bacillus acts as a putrefier it attacks albumoses and peptones; it is probably not capable of attacking undigested protein. The proteolytic bacteria, on the other hand, have the power of breaking down undigested protein.

Summary.—Most of our practical procedures in infant feeding, as regards intestinal conditions, are founded upon our knowledge of what causes fermentation, what putrefaction, the antagonism between the two, and a knowledge of how to diminish one or the other by changing the type of food offered. A knowledge of the principles of intestinal bacteriology, the processes of fermentation and putrefaction, and the chemical changes involved is indispensable to a thorough understanding of infant feeding. These principles will be referred to many times in the course of the following pages.

THE METABOLISM OF THE FOOD ELEMENTS

1. **The Metabolism of Protein.**—Protein in the food has a threefold function (Howland[1]):

1. Part of it replaces tissue waste (desquamated cells, secretions, etc.).

[1] Amer. Jour. Dis. Chil., vol. 5, 1913.

2. Part of it is retained by the body to build up tissue.
3. Part of it is burned and acts as a source of energy.

For the infant the most important function of protein is the second—as a tissue builder. The infant retains a considerable amount of protein each day, often as much as 55 per cent. of that which has been absorbed. Sugar and fat (the fuel part of the diet) act as nitrogen sparers, and when they are given in sufficient amounts to furnish adequate fuel for the body only a small portion of the protein need be burned, and most of it is available for purposes of growth. This is illustrated by the metabolism experiment of Talbot and Hill,[1] who found that increasing the amount of carbohydrate in the food markedly increased the retention of nitrogen. Thus, in a three-day metabolism period, their baby (J. P.) retained 2.06 gm. of nitrogen, corresponding to about 13 gm. of protein, when the carbohydrate intake was 216 grams. In the next three-day period the carbohydrate intake was 417 grams, and the retention of nitrogen was 3.16 grams, corresponding to about 20 grams of protein, which was nearly a third of the total amount of protein absorbed.

Minimum Protein Needs.—Chittenden's well-known work has shown that the minimum protein needs for the adult, in order to keep the body in nitrogenous equilibrium and to replace cell "wear and tear," are not high, and that it is possible to keep in nitrogenous equilibrium on about 0.73 gm. of protein per kilogram of body weight, provided adequate amounts of carbohydrate and of fat are given. One would naturally expect that the figures would be considerably higher for babies and children on account of the relatively large amounts of protein needed for growth. Such is indeed the case, although in babies and children it has not been possible to carry out any such extensive or accurate investigations as those of Chittenden for adults. About the only standard we have to go by is breast milk. We know that this is relatively low in protein, that most of its fuel value is furnished by the fat and sugar, that little of the protein in

[1] Amer. Jour. Dis. Chil., vol. 8, 1914.

breast milk is used for fuel, and that probably the amount which it contains represents the optimum amount to furnish nitrogen for growth. It is true that the biologic value of the protein of breast milk is somewhat greater than that of cow's milk protein on account of its constitution, being made up as it is of the most suitable amino-acids for cell growth. This difference is not great enough, however, to invalidate the use of the protein content of breast milk as a rough standard of comparison in artificial feeding.

A breast-fed baby of 8 kilograms ($17\frac{1}{2}$ lbs.) would take as a maximum not over 1000 c.c. of breast milk per day, containing about 12.5 grams of protein. This would furnish about 1.5 grams of protein per kilogram of body weight. Inasmuch as about 20 per cent. of the nitrogen of human milk is unavailable for use, being in the form of extractives, as Howland[1] has pointed out, this would mean only about 1.20 grams of protein per kilogram of body weight. The breast-fed baby can and does thrive then on this amount.

The usual amount that has been considered necessary in feeding with cow's milk is 1.5 gm. per kilogram. According to Hoobler,[2] if 7 per cent. of the total calories are given as protein calories, the nitrogen needs will be amply provided for. Or, as others have said, the protein contained in 1.5 ounces of whole milk per pound of body weight per day meets the protein requirement. As a matter of fact, there is little danger of going below the minimum protein need in any of the ordinary milk modifications used, and almost always considerably more than this is given, especially if whole milk dilutions are used, under which conditions the baby uses a considerable part of the protein intake for fuel.

In practical infant feeding, therefore, it is rarely necessary to calculate the protein requirements if at all reasonable concentrations of milk are employed. If condensed milk or certain of the proprietary foods are used, however, the protein intake is often too low.

[1] Loc. cit. [2] Amer. Jour. Dis. Chil., vol. 10, No. 3, 1915.

The Digestion and Absorption of Protein.—The casein of cow's milk is coagulated in the stomach into large tough curds; the whey protein does not undergo coagulation. The casein of human milk is precipitated in soft flocculent curds. The mechanism of the coagulation of casein is somewhat as follows: The gastric enzyme, rennin, acts upon the casein and converts it to paracasein. This paracasein then reacts with the calcium salts of the milk, and forms an insoluble curd consisting of a combination of paracasein and calcium (calcium caseinate). The fat of the milk is mechanically combined with the casein curd, probably by becoming entangled in its meshes.

A considerable portion of the calcium caseinate is broken down in the stomach by the pepsin, and hydrochloric acid into albumoses and peptones. The digestion is then carried on further by the trypsin of the pancreatic juice and the erepsin of the succus entericus, trypsin digestion being the more important. These ferments break down the albumoses and peptones into polypeptids and finally amino-acids, which are absorbed free or in combination with various salts. Trypsin is capable of attacking protein before it has been changed to albumoses and peptones, and probably normally does so, as some of the milk leaves the stomach so quickly after ingestion that there has been no time for digestion to take place.

The absorption of protein in health is good, from 90 to 95 per cent. of the intake being absorbed, and is equally good in both bottle- and breast-fed babies. The absorption is likewise good in most nutritional disturbances unless there is an associated diarrhea, under which conditions it is always poor.

Action of Protein in the Intestine.—The unabsorbed residue of protein food is alkaline in reaction, partly owing to the ammonia which may be formed, partly due to the large amount of calcium always ingested when high concentration of milk (with a high protein content) are fed, partly due to the fact that high protein feeding causes an increased pancreatic and intestinal secretion, both of which are alkaline in character. If small amounts of protein are ingested, together with large amounts of

carbohydrate, there will be little if any putrefaction in the intestine owing to the fact that in general the intestinal bacteria attack sugar in preference to protein, when plenty of sugar is offered, and the fermentation thus taking place inhibits putrefaction. If large amounts of protein and small amounts of carbohydrate are taken, the unabsorbed carbohydrate residue is small, and is insufficient to support a fermentative flora, so the proteolytic forms gain the upper hand, and the facultative forms, which can live upon either carbohydrate or protein, attack the protein, as there is no carbohydrate for them. The reaction of the intestinal contents when putrefaction is in the ascendancy is always alkaline (as in the normal bottle-fed baby). This is normal provided it is not excessive; if it becomes excessive the smooth, slightly foul, yellow, normal "high protein" stools change to the loose, brown, more foul stools of abnormal protein putrefaction.

2. **The Metabolism of Fat.**—Fat forms an important part of the food as regards calories, for 1 gram of fat furnishes 9.3 calories as against the 4.1 calories furnished by an equal amount of carbohydrate or of protein. It is not, however, so necessary to life as carbohydrate, provided an adequate caloric intake is furnished by the other food elements, and a baby may be fed over a considerable period on a fat-free diet without injury.[1]

Fat as it exists in milk is in the form of neutral fat, a combination of glycerin and higher fatty acids. During the process of digestion the neutral fat is split into these two component parts. The stomach contains a ferment capable of splitting a certain portion of the fat, but this is probably of relatively little importance, and most of the fat digestion takes place in the upper portion of the small intestine, where the steapsin of the pancreatic juice splits it into glycerin and fatty acids. The

[1] Recent work has shown that prolonged feeding on a diet containing an inadequate amount of fat may bring about arrested growth, and various disturbances of nutrition, probably on account of the lack of the fat-soluble vitamin.

fatty acids combine with alkaline carbonates in the intestine (Ca, Mg, Na, K) to form soaps, which are emulsified and made soluble by a combination with the bile and then absorbed. The soaps during their passage through the intestinal wall are resynthesized into neutral fat by ferments contained probably in the epithelial cells. The soaps formed are largely of the higher fatty acids (palmitic, stearic, oleic); the calcium soaps, especially that of palmitic acid, are relatively insoluble and are absorbed with difficulty. The sodium and potassium soaps are more easily absorbed. According to Bosworth, Bowditch, and Giblin[2] 100 gm. of butter fat when saponified yields 38 per cent. of palmitic acid, the calcium soaps of which are relatively insoluble. When the fat of human milk is saponified less palmitic and more oleic acid is produced, the soaps of oleic acid being more soluble than those of palmitic. In general, the lower the melting-point of a fat or fatty acid, the easier is its absorption. The melting-point of palmitic acid is high (62 degrees), that of oleic acid low (14 degrees).

The importance of the bile for fat absorption is shown by Parker's case, a girl with a biliary fistula of such a nature that no bile whatever reached the intestine.[2] In a three-day metabolism period he found that only 64 per cent. of the fat intake was split and only 55 per cent. was absorbed. The absorbed fat enters the lacteals, is carried to the circulation largely by way of the thoracic duct, and is used by the body as fuel, the end-products being carbon dioxid and water, or is deposited in various organs and tissues.

Percentage of Fat Intake Absorbed.—Fat absorption in health is remarkably good both in breast- and in bottle-fed babies. The most complete investigation of the subject is by Holt, Courtney, and Fales,[3] and the following data are taken from their publications:

Normal breast-fed infants were found to absorb an average

[1] Amer. Jour. Dis. Chil., vol. 15, No. 6, 1918.

[2] Ibid., vol. 5, 1913.

[3] Ibid., vol. 17, April and June; vol. 18, August and September, 1919.

of 95 per cent. of the fat ingested. The figures of other authors vary from 92 to 99 per cent. In 3 breast-fed infants who were not doing well (2 with diarrhea) the fat absorption was 79, 62, and 52 per cent.

Constipated bottle-fed babies were found to absorb an average of 90 per cent.; bottle babies with normal stools, 91 per cent. If the stools were slightly softer than normal the absorption sank to 88 per cent.; if they were loose, to 84 per cent., and if there was an actual diarrhea, the absorption was only 79 per cent.

According to all writers the lowest fat absorption occurs in diarrhea, and in severe cases may fall as low as 50 per cent. of the intake. The cause of the diarrhea need not be an excessive fat intake; apparently the low absorption is mostly due to the fact that the increased peristalsis hurries fat through the bowel so quickly that it cannot be absorbed, and partly to the changed chemical conditions that are present in the intestine with any diarrhea, whatever its cause.

In the stools of any bottle-fed baby there is a considerable amount of insoluble soap, but this does not necessarily mean a poor fat absorption. With typical, light colored, dry, alkaline soap stools there is probably always a poor fat absorption, although some of the earlier writers found it normal. This was probably due to faulty methods of analysis.

Bahrdt,[1] who in 1910 made an exhaustive study of soap stools, found that the fat absorption varied between 82 and 86 per cent. when typical soap stools were passed, which is a considerable difference from the normal average absorption. The chemistry of soap stools has been for years a subject of painstaking study, but the exact processes concerned in their formation are as yet not well understood. Dry, whitish-gray, crumbly stools occur in the condition, which was called by Czerny "Milchnährschaden," by Finkelstein "Bilänzstorung," and has been usually called in America chronic fat indigestion (see Chapter XI).

[1] Jahrb. f. Kinderh., 1910, lxxi, 249.

Soap stools, according to Howland,[1] are formed when three conditions are present in the food:

1. A moderate or a large amount of fat.
2. A large amount of calcium and of casein.
3. A lack of carbohydrate.

On account of the large amount of casein and of calcium present in the food and the lack of fermentable carbohydrate the intestine becomes alkaline and peristalsis is slowed. This favors the formation of insoluble calcium soaps, in just what way is not certain. The fat absorption becomes poor, as so much of the fat is changed into insoluble calcium soaps, which are absorbed with relative difficulty. There is also a very poor retention of calcium and magnesium, with a consequent relative acidosis and an ammoniacal urine. The subsequent impairment of nutrition, which may be severe if the process is unchecked, cannot be due to the loss of fat calories alone, as in most cases not more than 30 or 40 calories a day would be lost in this way over the normal amount. Fat must have something to do with the condition, however, as it is not seen except when there is a considerable amount of fat in the diet, and a baby may be fed on a fat-free food, no matter how rich in calcium or casein it may be, or how poor in carbohydrate, without developing this typical nutritional picture.

It is probable that the poor calcium retention is the most important single factor in producing the nutritional change which occurs, which is borne out by the fact that a good many of these babies develop rickets or spasmophilia, both conditions which are dependent upon poor calcium retention. The reason why the calcium retention should be poor is obscure, and cannot be accounted for entirely by the combination of calcium with unabsorbed fatty acids to form soaps, as Bahrdt[2] has shown that there is not enough fatty acid present to bind all the calcium that is excreted.

According to many authorities there is a primary deficient

[1] Amer. Jour. Dis. Chil., vol. 5, 1913.

[2] Loc. cit.

calcium absorption dependent upon increased excretion, and the formation of soap stools is a secondary matter.

Whatever the exact cause of soap stools may be, it seems to us that the process which brings them about is simply an exaggeration of that which occurs in the intestine of any normal baby fed on dilutions of cow's milk rich in casein and calcium and relatively low in carbohydrate. The normal stool of a bottle-fed baby is like a soap stool in a good many ways, it is alkaline, formed, slightly foul in odor, and contains a good deal of calcium soap. If the relations of the elements in the food are changed still further, so that the food is still lower in carbohydrate and higher in calcium and casein or fat, typical soap stools result, which differ essentially from the normal stools of a bottle-fed baby only in that they are very light colored, more constipated, and contain more calcium. The process is in no sense different in kind from that which produces the characteristic bottle-baby stools—it is different only in degree, and all gradations may occur between the yellowish-brown, formed normal stool, to the more constipated, larger, grayish-white soap stool. For this reason it is not always easy to tell what is a pathologic soap stool and what is not. The color, the large amount of fat seen under the microscope, and the condition of the baby are the most important criteria.

Fat Partition in the Stools.—Fat in the stools exists as neutral fat which has not been acted upon at all by the digestive juices, as fatty acid, representing fat which has been split, but not saponified, and as soap, which has been both split and saponified.

The total fat normally forms a large proportion of the dried weight of the stool. According to Holt, Courtney, and Fales,[1] in normal stools from breast-fed infants 42 per cent. of the dried weight consists of fat. Stools which were green and contained a good deal of mucus were found to contain only 23 per cent. of fat, on account of the relatively large amount of other material present (bacteria, mucus, etc.). In normal bottle-fed babies

[1] Loc. cit.

who were taking ordinary mixtures of cow's milk 36 per cent. of the dried stool consisted of fat, and in older children fed on a mixed diet the figure was 18 per cent. These lower figures for artificially fed babies and for older children are to be expected, as in bottle-fed babies there is a comparatively large residue of unabsorbed casein and calcium, and in children fed on a mixed diet, of cellulose. Most of the fat present is in the form of soap, especially if the stools are alkaline in reaction. If the stools are strongly acid there is a decrease in the percentage of soap and an increase in the fatty acid. Fat in an alkaline intestine tends to form soap; in an acid intestine, fatty acid; soaps tend to produce constipation; fatty acids, diarrhea. Thus it is that the effect of fat upon the intestine and upon the metabolic processes depends largely upon the reaction of the intestine, which, in its turn, depends upon the relative proportions of sugar and protein in the diet. When the sugar and protein are well balanced, and there is neither a strong alkaline or strong acid reaction in the intestine, large amounts of fat when ingested are more likely to produce acidity than alkalinity, on account of the fatty acids formed during digestion of the fat. It is also probable that bacteria attack undigested fat and break it down into fatty acid. The fatty acids which are formed from the breaking down of fat are higher members of the fatty acid group (oleic, stearic, and palmitic), are solid at ordinary temperatures (with the exception of oleic), non-volatile, and not particularly irritating to the intestinal mucosa. The lower members of the fatty acid group (acetic, butyric) are liquid, volatile, and extremely irritating to the intestine. It is theoretically possible that the lower members could be produced from the higher by still further splitting, and it is probable that this occurs to a certain extent when fermentative bacteria are active. It is probable, however, that this splitting does not take place to any great extent, and that when butyric and acetic acids are found in the stools they come from the sugar rather than from the fat. A diarrhea from sugar is likely, therefore, to be more irritating and profuse than one from fat, on

account of the greater irritating effect of the lower fatty acids arising from sugar decompostiton.

Fat splitting is almost always good except when diarrhea occurs, or excessively large amounts of fat are fed, therefore only a small portion of the stool fat ordinarily consists of neutral (unsplit) fat. If a large amount of neutral fat is found in the stools microscopically a severe fat incapacity is indicated. In most cases of "fat indigestion" the trouble is not an "indigestion" at all, but is a failure of absorption of the fat which has been digested.

Table I, from Holt,[1] shows the distribution of the fat in the stools of normal and abnormal bottle-fed babies, and of children on a mixed diet; Table II compares normal breast and bottle babies.

TABLE I

Type of stools.	Total fat per cent. of dried weight of stools.	Soap.	Per cent. of total fat as	
			Free fatty acids.	Neutral fat.
Constipated	36.0	73.8	17.6	9.0
Normal	36.2	72.8	16.5	9.4
Softer than normal	31.9	59.8	24.5	11.9
Not homogeneous	32.7	44.6	19.3	22.5
Loose	30.2	30.6	16.6	55.1
Diarrheal	33.4	12.4	30.4	61.6
Severely diarrheal	40.7	8.8	38.1	56.4
Older children on mixed diet. Normal stools	18.0	45.1	27.4	27.5

TABLE II

Food.	Type of stools.	Total fat per cent. of dried weight of stools.	Soap.	Per cent. of total fat as	
				Free fatty acids.	Neutral fat.
Cow's milk	Normal	36.2	72.8	16.5	9.4
Breast milk	Normal	42.1	57.8	26.3	15.9

[1] Loc. cit.

The most striking thing about this series of figures is the gradual diminution in the percentage of soap, and the rise in fatty acid and neutral fat as the stools become diarrheal.

It will be seen that the stools of the bottle-fed baby contain a higher percentage of soap and less fatty acid than those of the breast-fed baby. This goes back to the principle of "soap in an alkaline medium, fatty acid in an acid medium." The stools of a breast-fed baby are strongly acid on account of the relatively large amount of lactose and small amount of casein and calcium in breast milk. Those of a bottle-fed baby are likely to be alkaline on account of the relatively large amount of calcium and of casein in the food.

Summary.—The chemistry of fat in the intestine is perhaps the most complicated and the most important of that of any of the food elements. It is complicated on account of the three different sorts of fat that are present (neutral fat, fatty acids, soaps) and on account of the variations in the action of these substances according to the conditions present, and the quantities of the other food elements in the diet. It is important, because clinically failure of fat absorption represents one of the most important group of cases we are called upon to treat. There are so many theories concerned in the question of fat metabolism, so many varying views, and so much that we do not as yet understand clearly, or only half understand, that I have not attempted to give any extensive review of the literature, and the foregoing is only a brief outline of the subject. It should be enough, however, for a practical working knowledge.

3. **The Metabolism of Carbohydrate.**—In contradistinction to fat, carbohydrate is necessary to life: if a baby is fed on a carbohydrate-free diet for any length of time he dies from acidosis, on account of the abnormal and incomplete combustion of body fat with the resulting acetone bodies—diacetic acid, beta-oxybutyric acid, and acetone. A certain amount of carbohydrate is necessary to insure proper fat combustion. The exact minimum necessary for babies of different weights and ages is not known. Sugar is of great importance as a nitrogen

sparer, and has more power in this regard than does an isodynamic amount of fat. When carbohydrate (sugar) is given in the diet it is possible to establish nitrogen equilibrium at a much lower level than when protein alone or when protein and fat alone are ingested. Thomas[1] showed that a diet containing the large amount of 18.4 gm. nitrogen did not suffice to keep the adult body in nitrogen equilibrium when no carbohydrate was given. The reason for this is that the protein food is drawn upon so heavily for fuel in the body that not enough is left for the needs of growth and repair. This holds even more for infants than it does for adults, as the nitrogen needs of infants per kilogram of body weight are considerably greater than those of older persons. The importance of sugar for fuel is shown in breast milk, in which 48.7 per cent. of the calories is furnished by the sugar.

The Relation of Sugar to Gain in Weight and the Retention of Nitrogen and Salts.—The feeding of large amounts of sugar may cause a rapid increase in weight, provided the sugar is well digested. This is partly due to water retention, and high sugar feeding is particularly likely to bring this about because the deposition of glycogen in the body cells, which may be considerable after high sugar feeding, is possible only when accompanied by a retention of two or three times its amount of water. The considerable salt retention with high sugar feeding may also account for a part of the water retention. Thus we see many babies who have been fed on a one-sided high sugar diet who appear fat, and are perhaps above normal weight. The apparent robust health and weight in these cases is deceptive because it does not consist of healthy fat and muscle, but of water which has been retained in the body cells. Condensed milk babies are likely to be of this type.

Sugar is not without a good deal of influence upon the retention of the other food elements; up to a certain point the more sugar that is fed, the greater is the retention of nitrogen and salts, particularly of nitrogen. If the tolerance for sugar is

[1] Arch. f. Physiol., Suppl., 1910, p. 249.

TABLE III

Food.		Feces.						Absorbed.			Retention.		Gain or loss in weight.	Number of stools in period.	Character of stools.
Percentage composition of food.	Grams of sugar in food.	Total fat.	Soaps and fatty acid.	Neutral fat.	Nitrogen.	Ash.	Acidity of feces.[1]	Fat, per cent.	Nitrogen, per cent.	Ash, per cent.					
I F. 2.00 C. 5.63 P. 1.63	216.72	8.38	7.45	0.93	1.15	5.74	36.6	88.9	88.9	71.5	+2.06	+6.58	+50	5	Large, formed, hard, light yellow.
II F. 1.95 C. 7.32 F. 1.71	307.44	7.67	6.93	0.74	0.67	5.17	33.9	90.6	94.1	72.7	+2.27	+6.38	+3.15	6	Large, formed, hard, light yellow.
III F. 1.66 C. 9.93 P. 1.78	417.06	6.92	5.78	1.14	1.11	5.30	54.9	90.08	90.54	68.50	+3.16	+4.76	+275	3	Formed, but much softer than before. Very large. One green stool.
IV F. 1.53 C. 9.16 P. 1.71	336.12	14.46	8.46	6.00	2.01	7.17	255.0	74.99	79.58	43.59	+1.80	−60	−185	12	Large, watery, green, with many small soft curds, and considerable mucus.

[1] Expressed in cubic centimeters of N/10 HCl.

overstepped, and fermentation results, the retention of nitrogen, and especially of salts, may be greatly diminished. This is of considerable importance in practical infant feeding and is illustrated in Table III, from some investigations carried out by Dr. Fritz Talbot and myself in 1914.[1] The effect on the retention and absorption of the other food elements of gradually increasing the amounts of sugar in the diet of a six months' old baby was studied in several metabolism periods of three days each. In the first three periods the baby was doing well, his absorption was good, and as the sugar in his diet was increased there was an increasing retention of nitrogen and gain in weight. In Period IV his sugar tolerance was overstepped, and he reacted with loose, green, acid stools, causing a poor absorption of all the food elements, a great increase of neutral fat in the stools, and a negative ash and nitrogen balance.

Digestion and Absorption of Sugar.—The three common sugars used in infant feeding—lactose, sucrose, and dextrin—maltose preparations, are disaccharids of complex formula, and must undergo splitting in the intestinal tract before being absorbed. Glucose is a monosaccharid, and is absorbed as such without further digestion. It is probable that sugar is normally acted upon very little in the stomach. It is broken down in the small intestine by the intestinal ferments into two molecules of a monosaccharid, and is absorbed as such. For each sugar there is a specific ferment: for lactose, lactase; for maltose, maltase; and for sucrose, invertin. The absorption of sugar in health is excellent, and most investigators have been unable to find sugar in the stools of normal babies. In cases where sugar is not being well absorbed, it is broken down by bacterial action into acid end-products, and thus, even in sugar indigestion, it is not usual to find sugar in the stools. If there is excessively vigorous intestinal peristalsis, and large amounts of sugar are ingested, the sugar may be hurried through so quickly that the unabsorbed residue may not have time to be completely fermented, and small amounts may be found in the stools.

[1] Amer. Jour. Dis. Chil., vol. 8, September, 1914.

Normal Action of Sugar in the Intestine.—In the breast-fed baby there is always a certain amount of sugar fermentation going on in the large intestine caused by the fermentative acidophilus and bifidus flora. Lactic acid and to a certain extent acetic and other volatile acids are the end-products of the fermentation, and serve to promote peristalsis and consequent evacuation of the bowel. In the large intestine of the bottle-fed baby, however, putrefactive processes predominate, and under normal conditions sugar fermentation is not so extensive. It has been shown that a slight amount of sugar fermentation in the large intestine is beneficial, and that the absorption and retention of the other food elements is aided by it. Large amounts of sugar in the food are likely to cause loose stools; the lack of sugar favors constipation.

Assimilation Limits of Different Sugars.—A baby takes relatively much more sugar than does an adult, and the assimilation limit, or the amount of sugar ingested per unit of body weight before sugar appears in the urine, is much higher in infancy than it is in later life. A breast-fed baby of 4 gm. would normally take perhaps 120 gm. of milk at a feeding, containing, roughly, 8.4 gm. of lactose, or 2.1 gm. per kgm. of body weight.[1] An adult usually shows sugar in the urine after taking about 1 gm. of sugar per kilogram of body weight.

Langstein and Meyer have calculated that an adult of 150 pounds would take about 800 gm. of sugar per day if he took as much in proportion to his weight as a 12-pound breast-fed baby.

Practically speaking, it is difficult to exceed the assimilation limit of a baby before sugar fermentation and diarrhea occur.

Porter and Dunn[2] in a series of cases fed large amounts of sugar to babies (from 7 to 18 per cent., or 90 to 225 gm. in twenty-four hours) with the purpose of determining how much sugar could be taken without digestive upset and also if the assimilation limits could be exceeded before diarrhea occurred.

[1] Langstein and Meyer, Säuglingsernährung und Säuglingsstoffwechsel, Weisbaden, 1910.

[2] Amer. Jour. Dis. Chil., vol. 10, No. 2, 1915.

They found that surprisingly large amounts could be taken without digestive disturbance, and although sugar occurred in the urine in some cases during the course of sugar diarrhea, its occurrence bore no relationship to the amount of sugar ingested. They conclude that much larger quantities of sugar can be taken without the development of intolerance than has been ordinarily supposed, and that it is not possible to exceed the sugar assimilation limits, so that sugar occurs in the urine before symptoms of sugar indigestion have occurred.

The assimilation limits of the different sugars vary somewhat, that of lactose and sucrose being about equal, from 3.1 to 3.6 gm. per kilogram of body weight, that of maltose considerably higher, about 7 gm.

Sugar Fermentation.—It is now generally granted that bacterial fermentation of sugar in the intestine plays a very important part in digestive and nutritional disturbances. A number of different agencies may bring this about, but the end-result is the same: excess of acid from the breaking down of the sugar, with consequent irritation of the intestinal mucous membrane. The production of acid is the first step in the chain of processes which may occur, and which may produce mild or severe conditions in the baby, depending upon how far they are allowed to go. It is probable that the unchanged sugar molecule is without much influence, and that it must be broken down into volatile acids before harmful results are brought about. This chemical change is produced by the action of bacteria upon sugar, and it is probable that it cannot be done in any other way.

Let us consider for a moment the chemistry of sugar fermentation, and the products that are formed. Lactose is a disaccharid, a rather complex chemical substance, with the formula $C_{12}H_{22}O_{11}$, containing many carboxyl and some aldehyd groups which may be very readily changed over into acid radicals. It will be seen from this that there is possibility for the formation of a considerable number of end-products when the molecule is torn apart, and that from the chemical con-

stitution of sugar acids are the substances which are most likely to be formed. Two different groups of acids may result from the breaking down of sugar: the so-called volatile "fatty" acids and the non-volatile acids. The non-volatile acids are lactic and succinic acids and probably do no harm. It is the volatile fatty acids with which we are chiefly concerned. There are thirteen members in this acid series, as follows:

Name of acid.[1]	Formula.
Formic	HCOOOH
Acetic	CH_3COOH
Propionic	$C_3H_6O_2$
Butyric	$C_4H_8O_2$
Valeric	$C_5H_{10}O_2$
Caproic	$C_6H_{12}O_2$
Heptylic	$C_7H_{14}O_2$
Caprylic	$C_8H_{16}O_2$
Nonylic	$C_9H_{18}O_2$
Capric	$C_{10}H_{20}O_2$
Palmitic	$C_{16}H_{32}O_2$
Margaric	$C_{17}H_{34}O_2$
Stearic	$C_{18}H_{36}O_2$

The lower members are liquids; the higher ones, beginning with C_{10}, are solids at ordinary temperature. It is the lower members of the group which are most important, and it is unlikely that the higher ones are formed by the breaking down of sugar. The higher acids are formed by the breaking down of fat, and it is also theoretically possible that the lower acids (formic, acetic) may be likewise formed from fat destruction. Probably always when there is a fermentation of sugar going on in the intestine there is also a secondary fermentation of fat, and it is quite impossible to tell how much of the acid formed comes from the one, how much from the other. The modern German school is inclined to attach very little importance to fat fermentation; they believe that it is practically always secondary to sugar fermentation and does little harm. Salge, in his important monograph in 1906, believed, however, that *all* the trouble came from the fat, and none from the sugar.

[1] Holleman, Text-book of Organic Chemistry.

Chemically, both substances can form acids very easily, and it is probable that in many cases the sugar and the fat *both* play an important part.

Bokai[1] found that the acids were irritating to the intestine in the following order: caprylic, caproic, acetic, propionic, formic, butyric, valeric. Bahrdt and Bamberg[2] believe that acetic is the most irritating. Increased amounts of volatile fatty acids in the intestine may bring about the following harmful changes:

1. Increase peristalsis by irritating the intestine, with diarrheal stools as a result; these loose stools may carry out a good deal of undigested fat and protein which have not had time for absorption.

2. Injure the mucous membrane of the small intestine in such a way that it is unable to exert its normal antibacterial powers. Also, the functionally injured mucous membrane may allow the passage of harmful substances (lactose(?), salts, acids, or bacterial endotoxins) into the system, which would not be able to pass the healthy intestine. This may lead to severe intoxication.

3. Draw upon the alkali reserve of the body in an attempt to neutralize the excessive acidity. This may help to cause an acidosis.

4. Upset the normal chemical processes of digestion, most of which cannot go on satisfactorily in an excessively acid intestine.

Conditions Which Bring About Sugar Fermentation.—Two things are necessary for sugar fermentation: undigested sugar free in the intestine and bacteria in sufficient quantity to attack it. It must be remembered that there is no specific bacterium which accomplishes this; it may be done by a number of different organisms, either the normal inhabitants of the intestine or harmful organisms introduced from without. The place of fermentation is of a good deal of importance; in the breast-fed baby fermentation in the large intestine is normal; in the bottle-fed baby who is sick on account of sugar fermentation the process

[1] See Tobler, ref. 566. [2] Ztsch. f. Kinderheilk., 3, 322, 1911, 1912.

may be taking place in the small as well as in the large bowel. A difficult problem in artificial feeding is to keep down excessive intestinal putrefaction, with the formation of constipated alkaline calcium soap stools, without going to the extreme of excessively acid sugar fermentation. These two conditions are largely controlled by the relation between the different food elements in the mixture offered to the baby. (See section on Bacteriology.)

The following seven conditions may produce abnormal sugar fermentation. I shall discuss in this section only the last one—high sugar in combination with high salts—and will take up the others in subsequent chapters.

1. Bacteria introduced from without in bad milk.
2. Overfeeding with sugar.
3. Overheating of the baby's body.
4. "Parenteral" infections.
5. Nervous influences.
6. Constitutional weakness.
7. High sugar in combination with high salts.

The German school has contended that perhaps the most important cause of sugar fermentation is a depression of the antibacterial powers of the epithelial cells of the small intestine by the salts of the cow's milk, particularly those salts which are left behind in the whey after the curd has formed. This lowering of resistance allows bacteria to flourish in the small intestine where they would not normally be able to exist except in very small numbers. It is an ingenious attempt to explain many little understood phenomena, but does not rest upon a firm enough substratum of observation and investigation to be unconditionally accepted as the truth. The importance ascribed to the whey salts is based largely upon Meyer's investigation, in which he separated breast milk and cow's milk each into curds and whey, and then added the whey of breast milk to the curds of cow's milk, and vice versa. He found that the mixtures containing the cow's whey caused diarrhea when fed in conjunction with a high sugar; those containing the whey of breast milk did not.

There is no question that cows' whey is rich in salts. It contains about 0.80 to 0.90 per cent. salts, in the form of chlorids, citrates and phosphates of sodium, potassium, and calcium. About half of the calcium of the original milk is present in the whey; probably nearly all of the sodium and potassium.[1] There is a certain amount of evidence to show that strong solutions of salts may depress the functions of living cells, but the salt concentration of cow's whey, although higher than that of human whey, corresponds to a physiologic saline solution only. It is hard to see how a concentration of salts which is thus practically isotonic with the body fluids can act in an injurious manner to the intestinal cells. Again, we know that plain whey, undiluted, is usually borne very well by even the smallest babies, and often is fed to them with great success during gastro-intestinal disturbances of various sorts, when the casein and fat of cow's milk, perhaps, cannot be borne at all. Also when we add sodium citrate in the strength of 1 or 2 grains to the ounce of milk and cream in the mixture, to modifications to favor the digestion of the protein, we are adding a large amount of sodium and of citrate ions, which does not seem to upset the baby. Again, when we add calcium chlorid to a baby's milk in order to lessen nervous irritability in spasmophilia, we add much more than is ever present in whey. Neither does this ordinarily upset the baby.

One of the chief purposes of the famous "Eiweissmilch" was to dilute the whey salts, but in eiweissmilch we have all the salts of the buttermilk used in its preparation, which in the finished eiweissmilch would correspond approximately to a salt concentration obtained by dilution of cow's milk one-half with water. Eiweissmilch works; there is no question of that; but is not its beneficial effect due rather to a very low sugar content (1.5 per cent.) than to a low salt content, which it does not contain? Let us suppose a baby was having dyspepsia on a dilution of one-half milk with added sugar; we would feed him eiweissmilch, and it would probably arrest the sugar fermenta-

[1] Bosworth: Personal communication.

tion, but we would not have decreased the salt content of his food at all.

The work of Courtney and Fales,[1] under the direction of Dr. Holt, is interesting in this connection:

"Protein milk contains a higher ash and higher amount of all the different salts than are ordinarily given to infants artificially fed. As compared with woman's milk, not only are the total salts of the ash in great excess, but the amount of calcium is nearly five times and the phosphorus nearly seven times as great. The soluble salts, also, are nearly twice as abundant in protein milk as in human milk. As used at the Babies' Hospital extensively for three years, with most satisfactory results, eiweiss-milch has contained, owing to the addition of sodium chlorid to the buttermilk used, an amount of Na and Cl nearly as great as in undiluted cow's milk, and much greater than in woman's milk. The following table shows the salt content in percentages of protein, cow, and human milk":

	Total ash.	CaO.	MgO.	P_2O_5.	K_2O.	Na_2O.	Cl.
Protein	.648	.201	.021	.222	.109	.032	.061
Cow	.743	.176	.020	.206	.189	.050	.111
Human	.206	.047	.008	.034	.057	.014	.035

It can be seen from these few suggestions that the question of the harmfulness of the whey salts is not at all a clear one, and that Meyer's original suppositions can be by no means unconditionally accepted. There is no question that breast milk, even with its high sugar content, can often be fed with beneficial results to babies who are suffering from sugar fermentation. Sugar fermentation must, therefore, be due in these cases to sugar plus some indeterminate factor present in cow's milk and not present in breast milk. There is evidently some property of breast milk which allows its high sugar content to be handled by the baby without undue fermentation; whether this is due to the relatively low salt content of breast milk or to other factors is by no means certain.

[1] Amer. Jour. Dis. Chil., vol. 10, 1915, p. 172.

Starch is a polysaccharid, a more complex form of carbohydrate than the sugars, and must be broken down into sugar before it can be absorbed. Its absorption is, therefore, slower than that of the sugars. It is probable that mouth digestion of starch is very slight in young babies, although the saliva has been shown to contain active ptyalin. The amylopsin of the pancreatic juice breaks down the starch first into dextrins, then into maltose, and the maltose is in turn changed to dextrose by the maltase of the succus entericus, and is absorbed as such. All the starch-splitting ferments have been found at birth, although their power is feeble during the first few months, and they do not become strongly developed until the end of the first year. Absorption of starch when given in moderate amounts, as cereal gruels to young babies, is good, and it is probably true that starch in this form could be used with advantage a good deal earlier than it usually is.

If starch is not well digested, it either comes through the stools as a foreign body, partly or entirely digested, or may be attacked by the intestinal bacteria and slowly fermented, with resulting end-products consisting mostly of volatile acids.

4. **The Metabolism of the Mineral Salts.**—The salts are of very great importance in the normal and abnormal processes of infant nutrition, and in the last fifteen years especially an enormous literature has grown up regarding them. So much has been written, so varying have been and still are many of the opinions held and the figures given, so complicated is the question of the metabolism of any individual mineral element, to say nothing of its relations to the other salts and the organic elements of the diet, that it is hard indeed to separate the wheat from the chaff, and to present in a clear and non-tedious way what seem to be the main facts of the subject that are of interest to practical medical men.

It is probably true that the clinical pictures produced by many "food injuries" are due very largely to disturbed salt metabolism, and in certain instances it is possible to know with a fair degree of accuracy what has brought about this perversion,

and how to correct it by changes in the diet, but in general there are far more theories concerned in discussions of disturbances in salt metabolism than well ascertained and universally accepted facts, and it is not ordinarily possible in practical infant feeding to vary the amounts of the various mineral elements in the food offered to the infant with the same degree of accuracy that we vary the organic constituents.

Cow's milk contains a much larger quantity of mineral material than does human milk, about 7.8 gm. to the liter for the former, 2 gm. to the liter for the latter. The salt metabolism of the bottle-fed infant is, therefore, on an entirely different plane from that of the breast fed. The salts are in much the same relative proportions in cow's milk as in human milk, with the exception of phosphorus and iron.

According to Holt, Courtney, and Fales[1] 100 gm. of ash contain the following:

	CaO.	MgO.	P_2O_5.	Na_2O.	K_2O.	Cl.
Human milk..	23.3 gm.	3.7 gm.	16.6 gm.	7.2	28.3	16.5
Cow's milk....	23.5 "	2.8 "	26.5 "	7.2	24.9	13.6

Iron is the only mineral element that is present in smaller quantities in cow's than in human milk. There are three especial points which must be borne in mind in reviewing the question of salt metabolism:

1. The analytic methods that have been used have often been faulty (especially for calcium and iron), and, therefore, many of the older figures are not accurate.

2. Often reports have been made on the salt metabolism of one infant over a relatively short period of time, and these figures have been used as the standard, being passed on from book to book.

3. A large portion of the intake of mineral salts (especially calcium) is re-excreted in the intestine after absorption; therefore it is not possible to get any accurate figures as to the amounts which have actually been absorbed. This must be

[1] Amer. Jour. Dis. Chil., vol. 10, 1915.

borne in mind in considering the figures for absorption, whether for total ash or for individual salts, and by "absorption" is ordinarily meant the difference between the intake and what appears (either re-excreted or unabsorbed) in the stools.

Physiologic Importance of the Salts.—Hoobler[1] has summarized very clearly the physiologic importance of the salts:

"(1) They maintain the osmotic pressure in tissue cells, blood, and body fluids; controlling the flow of water to and from the tissues; any deviation from normal causing a shrinking or swelling of tissue cells.

"(2) They regulate the reaction of the blood and tissue fluids. A deviation from this reaction inhibits the action of the various ferments, delays chemical processes, and, if such reaction suffers much variation, death results (acidosis).

"(3) Their presence in tissues and fluids gives rise to irritability of muscle and excitability of nerve through the action of their respective *ions*. Through this function the rhythmic contractions of the heart are maintained.

"(4) They act as catalysts for a large series of chemical reactions which take place during the processes of absorption, retention, utilization, and form combinations with waste products of metabolism in order to effect their elimination; for example, they act as carriers of excess acid materials in oxidation processes.

"(5) They share in the upbuilding and growth of the body, since they are a constituent of every cell; particularly do they take part in the changes which go on in the albumin bodies as they become intimately bound with the body proteins.

"(6) Their function in the intermediary metabolism of the ductless glands is very apparent from the large quantities of mineral salts found in these organs.

"(7) Through a most excellent self-regulation they protect against the acid poisons which the body is constantly producing.

"(8) Through the work of the various *ions*, electrically charged, some positively, some negatively, many important

[1] Amer. Jour. Dis. Chil., vol. 2, 1911.

functions are being assigned to them, such as controlling body weight, temperature, regulating the pulse, increasing leukocytes, etc. These and many more functions, not clearly defined, depend upon the presence of the mineral salts in the body, and not on their presence alone, but their presence in definite relationships to one another."

(9) They form an important part of all the digestive juices. (L. W. H.)

Total Ash.—1000 c.c. of cow's milk contains 7.8 gm. of total ash; 1000 c.c. of human milk contains 2 gm. of total ash.

The absorption of ash is not so good as that of the inorganic food elements. According to different observers, the percentage absorption varies from 65 to 75 per cent. in the bottle-fed babies, and is somewhat higher for the breast fed. The actual absorption is higher in the bottle fed.

In any diarrhea the absorption may be very poor, so that there is an actual negative salt balance, with a loss of mineral substance from the body. This is important clinically and undoubtedly has a great deal to do with the clinical picture seen in severe cases of diarrhea.

Calcium and Magnesium.—1000 c.c. of human milk contains 0.42 gm. of CaO and 0.082 gm. of MgO; 1000 c.c. of cow's milk contains 1.72 gm. of CaO and 0.20 gm. of MgO.

Calcium is present in cow's milk in three different forms (Bosworth[1]):

1. As insoluble phosphate, which is practically inert, is not absorbed, and is recovered in the stools as such.
2. Combined with protein as calcium caseinate.
3. As soluble salts in the whey.

It is not possible to tell accurately how much calcium is actually absorbed, as the excretion of calcium in the bottle fed takes place almost entirely through the intestine, and only a small amount is excreted through the urine. According to Bosworth the calcium metabolism of the bottle-fed baby is seldom greater than that of the breast-fed baby, and may actually be

[1] Amer. Jour. Dis. Chil., vol. 15, 1918.

less, even if there is more calcium in the food, as most of the calcium is eliminated in the feces as insoluble calcium phosphate and calcium soaps.

	Breast baby (gm. per 240).	Bottle baby (gm. per 240).
CaO in urine..................	0.069 gm.	0.025 gm.
CaO in feces..................	0.038 "	1.672 "

The figures given for the absorption of calcium vary so much that it is impossible to draw any very exact conclusions from them. The methods used for analysis, the age and nutritional condition of the baby, the amount of calcium in the food, and its relation to the other food elements probably account for these differences. From a study of the figures available it would seem that the percentage absorption in babies fed on cow's milk is low, and that the percentage absorption, although not the actual absorption, is certainly a third greater, and perhaps nearly twice as great in the breast fed as in the bottle fed. The latest and probably the most reliable work is by Holt, Courtney, and Fales,[1] who found that bottle-fed babies absorbed from 35 to 55 per cent. of the intake, while breast-fed babies absorbed 66.7 per cent.

"The average absorption of CaO for 5 healthy breast-fed babies was found to be 0.054 gm. per kilogram. Since infants taking cow's milk absorb only about 45 per cent. of the calcium intake, it is necessary to provide for them a minimum intake of 0.130 gm. CaO per kilogram of body weight in order to have them absorb as much as a breast baby."

Since cow's milk contains on an average of 1.72 gm. CaO per liter, ½ liter of milk would amply cover the calcium needs of a baby of 6.5 kgm. or about 14½ pounds. A baby of about 20 pounds would require, according to these figures, 1.17 gm. CaO per day, and would be getting considerably more than this in a liter of milk. If these figures are correct there is, therefore, little danger of not covering the calcium needs of infants with the ordinary methods of feeding, especially as usually after the eighth

[1] Loc. cit.

or ninth month cereal is added to the diet, which contains a not inconsiderable amount of calcium.

The three pathologic conditions which are of most importance in connection with abnormal calcium metabolism are chronic fat indigestion (Bilanzstörung), rickets, and spasmophilia. Rickets and spasmophilia will be discussed later.

The relation of calcium excretion to the fat in the diet has long excited interest, and many metabolism experiments have been carried out to determine what effect increasing amounts of fat in the diet had upon calcium absorption. The consensus of opinion seems to be that increased fat in the diets of normal babies does not decrease calcium absorption (Holt, Courtney and Fales,[1] Meyer,[2] Aschenheim[3]).

As regards babies who have a chronic incapacity for fat, particularly those who pass the colorless, dry, constipated stools which contain a large excess of soap, the conditions are quite different, and there may be a large loss of calcium in such stools, enough in many cases to cause a negative calcium balance. According to Meyer,[4] in Bilanzstörung (chronic fat indigestion) as much as 60 per cent. of the calcium intake may be lost in these stools, but soap stools in themselves do not always mean that there is an increased calcium output or a negative calcium balance. One can only say that very frequently when typical soap stools are passed there is a negative calcium balance. Bosworth, Bowditch, and Giblin[5] believe that the large excess of calcium in cow's milk is the prime reason why certain infants suffer nutritional disturbance when considerable amounts of fat are taken, and they have shown in these cases that it is possible by feeding a decalcified milk to greatly increase the tolerance toward fat. In one of their cases the total fat in the stools dropped from 4 gm. per day to 0.66 gm. per day as soon as the feeding with decalcified milk was started, and they have found

[1] Amer. Jour. Dis. Chil., vol. 19, 1920.
[2] Jahrb. f. Kinderh., 71, 1, 1910.
[3] Ibid., 77, 1913.
[4] Loc. cit.
[5] Amer. Jour. Dis. Chil., vol. 15, 1918.

that many infants who on ordinary milk mixtures are able to handle practically no fat at all, thrive on as much as 3 per cent. when the decalcified milk preparation is used. In spite of much research on the subject the interaction of fat and of calcium and their relative importance in chronic fat indigestion are still obscure. We know that in many cases where there is poor utilization of fat there is also pure utilization of calcium; we know that the simple loss of calories from the poor fat absorption is not enough to account for the disturbance of nutrition; we know that the loss of calcium is not entirely accounted for by a simple binding with fatty acid to form insoluble calcium soaps; still, the characteristic nutritional change does not occur unless fat and calcium are both present in relatively large amounts, and it never occurs in infants fed on breast milk, where the fat is high and the calcium is low. About all that can be said in the present state of our knowledge is that in some babies high fat plus high calcium is not well tolerated.

Magnesium.—There is only a small amount of magnesium in either cow's or human milk. It is not so important as calcium in the pathogenesis of nutritional disturbances, but being closely allied to it chemically, in general acts in the same way, and forms insoluble soaps with fatty acids. The percentage absorption of magnesium is about the same as that of calcium.

Sodium and Potassium.—1000 c.c. of cow's milk contains 0.46 gm. of Na_2O and 1.72 gm. of K_2O; 1000 c.c. of human milk contains 0.16 gm. of Na_2O and 0.88 gm. of K_2O.

The absorption of both sodium and potassium is relatively better than that of the other salts, from 75 to 90 per cent. of the intake being absorbed. They are excreted partly through the urine as phosphates and chlorids, and partly through the intestine (digestive juices). In diarrhea the sodium and potassium absorption especially suffers, and there may be a negative balance, while the calcium and magnesium balance is positive. With constipation, especially of the soap stool type, there is likely to be a good and perhaps in certain cases an excessive retention of sodium and potassium. There is normally a certain fairly defi-

nite balance between the amount of sodium and potassium in the body, on the one hand, and the calcium and magnesium on the other hand, which is necessary to preserve the proper degree of nerve irritability. If too little calcium and magnesium and too much sodium and potassium are retained, a condition of increased nerve irritability is likely to result (see Spasmophilia). Sodium and potassium are also important in furnishing alkali for the pancreatic and intestinal digestive juices, and for the bile.

Phosphorus.—1000 c.c. of cow's milk contains 2.25 gm. of P_2O_5; 1000 c.c. of human milk contains 0.40 gm. of P_2O_5.

Phosphorus is needed especially by the body for the formation of bone, glandular tissues, and the central nervous system. Part of the phosphorus present in milk is in organic form contained in the milk casein, partly in inorganic form. In cow's milk a large part of the phosphorus exists as insoluble calcium phosphate, which is inert as far as metabolism is concerned, and goes through the intestinal tract quite without absorption (Bosworth). In cow's milk a much greater amount of phosphorus is present than can possibly be used by the baby, and the percentage absorption is not nearly so high as that of the phosphorus contained in breast milk, although the actual absorption may be more. The figures given by various authors for phosphorus absorption vary between 53 and 83 per cent. for cow's milk and 65 and 89 per cent. for human milk. The breast-fed baby excretes only traces of phosphorus in the urine, and the bottle-fed baby may excrete a fifth or a sixth as much in the urine (0.34 gm.) as he does in the stools (1.67 gm.) (Bosworth). According to Hoobler the elimination through the urine and intestine is about equal.

Iron.—1000 c.c. of cow's milk contains 0.0006 gm. of Fe_2O_3; 1000 c.c. of human milk contains 0.0017 gm. of Fe_2O_3.

On account of faulty methods of analysis there seems no question that the older figures given for iron were altogether too high, and that both human and cow's milk contain only very small amounts. It is the only mineral element which is

present in smaller quantities (one-third as much) in cow's milk than in human milk, and when cow's milk is diluted, as it is in infant feeding, the amount of iron present is almost negligible. Despite this, babies seem to thrive during the first eight or nine months, at any rate, on dilutions of cow's milk which contain practically no iron. It is a clinical fact that babies after this time are likely to become anemic, whether bottle or breast fed, if additional iron-containing food is not given. This is especially true of premature infants and twins. It is well known that the newborn infant contains a considerable store of iron in the liver, which probably acts as a reserve depot, and it is supposed that this accounts for the fact that the bottle-fed baby gets along on a food containing only traces of this element. The iron needs of babies are not definitely known, and the only data available is the iron intake of the naturally fed infant, who is supplied about 1.5 mgm. Fe_2O_3 per day in his ration of breast milk. Soxhlet[1] calculated that if a baby gained 25 gm. in weight a day there would be a daily gain of 1.92 gm. of blood, which would require 1.34 mgm. of iron oxid. This amount is well covered by the breast milk. It is likely that in the early months of life more iron is excreted than is taken in (Blauberg, Camerer), and as long as the fetal iron deposit in the liver is taking part in the iron metabolism it is not possible to determine the amount or iron absorbed or retained.

From a practical point of view it seems certain that the iron in the liver plus the very small amount contained in cow's milk modifications is enough to cover the iron needs of artificially fed babies for the first eight or nine months at any rate. These needs must, therefore, be very small, and if after the eighth month food is added which contains only a very small amount of additional iron, there is no danger of anemia developing.

Sulphur.—1000 c.c. of cow's milk contains 0.33 gm. of SO_3 (Hoobler); 1000 c.c. of human milk contains 0.14 gm. of SO_3 (Blauberg).

According to Hoobler the percentage of sulphur absorbed

[1] Münch. med. Woch., vol. 59, 1912.

varies from 88 to 95 per cent. Most of the sulphur in milk is a constituent of the casein.

Chlorids.—1000 c.c. of cow's milk contains 0.82 gm. of Cl; 1000 c.c. of human milk contains 0.34–0.59 gm. of Cl.

The absorption is from 90 to 95 per cent. of the intake. The excretion is largely through the urine, as sodium chlorid, except in diarrhea, when considerable amounts may be lost in the stool.

5. **The Vitamins.**[1]—It is now recognized that, in addition to fat, carbohydrate, salts, and water, food-stuffs contain other substances which are necessary for proper growth and maintenance. These substances have been variously called "vitamins," "accessory" food factors, and "fat-soluble A," water-soluble "B" and "C." In 1897 Eijkman, who was studying the Eastern disease beriberi, found that pigeons who were fed solely upon polished rice developed in three or four weeks a condition of paralysis, which was a polyneuritis, and was analogous to beriberi in man. When instead of being given polished rice they were fed upon whole rice kernels they did not develop beriberi, and, furthermore, it was found that the administration of rice polishings would cure the disease after it had developed. The natural inference was that it was caused by a lack of some unidentified substance or substances contained in the rice polishings. In 1912 Hopkins found that maintenance of body weight and growth in rats could not proceed with a diet of purified food substances, but that if milk was added growth proceeded. He suggested the existence of unidentified food substances which were supplied by the milk, and gave them the name of "accessory" food factors. In 1914 Funk called these substances "vitamins" and believed that beriberi, scurvy, and rickets were caused by a lack of them in the diet. McCollum and Kennedy, who had been for some time working along

[1] Only a very brief outline of this fascinating subject is possible here. If the reader desires to go further with it he is referred to that most interesting book of E. V. McCollum's, "The Newer Knowledge of Nutrition" (Macmillan Co., 1918), of which I have made free use in this section, and to the Journal of Biological Chemistry, 1915–1921, in which most of the original articles concerning the vitamins have appeared.

the same lines, believed that there were two substances, and suggested for them the names fat-soluble "A" and water-soluble "B." Still later a third substance was believed to be present, and was called water-soluble "C." While it is true that the word "vitamin" has certain objections as a term of nomenclature for these substances, it is the one most commonly used to designate them collectively. The individual vitamins are best spoken of as fat-soluble "A," etc.

Nature and Occurrence of the Vitamins.—The chemical constitution of the vitamins is unknown, and they have never been isolated in pure form. Funk believed that they were nitrogenous bodies chemically allied to the amins, hence the term "vitamins." It is probable, however, that this view is erroneous, at least for the fat-soluble "A," as it occurs in fats, which contain no nitrogen. They cannot, apparently, be produced in the animal body unless food containing them is ingested, and the amount of vitamin in milk, for example, has been found to be directly proportional to the vitamin content of the food eaten by the cow. Fat-soluble "A" and water-soluble "B" are comparatively stable substances, not easily destroyed by heat or other agencies, while the water-soluble "C" is more easily destroyed by heat, oxidation, alkalies, or aging of the food in which it exists. Fat-soluble "A" occurs especially in butter fat, cod-liver oil, the fat of egg yolk, and the leaves of plants (spinach). It occurs to a slight degree in the roots of vegetables, such as carrots. It does not occur in vegetable oils, and only slightly in most animal fats, such as lard or beef fat. Water-soluble "B" is found especially in milk, the outer covering of the seeds of plants (rice, oats, wheat), and in brewer's yeast. Water-soluble "C" occurs especially in fruit juices and vegetables, and to a lesser extent in milk, germinated cereal grains, and meat. It does not occur in cereal grains that are not germinated.

Action of the Vitamins.—FAT-SOLUBLE "A."—A lack of this in the diet causes lack of growth and a peculiar disease of the eyes called xerophthalmia, manifested especially by an inflammation of the cornea and possible blindness. Much experi-

mental work has been done on animals (rats) by several investigators, with diets lacking the fat-soluble "A" factor, and failure of growth and xerophthalmia have been regularly produced. As soon as food-stuffs containing this factor are added to the diet, such as butter fat, cod-liver oil, or spinach, growth proceeds, and the eye condition is cured in a very few days. It has been held by some that a lack of fat-soluble "A" is the cause of rickets, but this is by no means assured (see chapter on Rickets).

Water-soluble "B."—A lack of this causes beriberi and possibly retarded growth. As far as is known it has no other specific action.

Water-soluble "C."—A lack of this in the diet causes scurvy, which can be readily cured by the ingestion of food-stuffs (fresh milk, fruit juices, vegetables) which are rich in it (see chapter on Scurvy).

Practical Importance of the Vitamins in Infant Feeding.—The subject is a new one, and, like all new discoveries in medicine, has been somewhat overdone. There is no question that there are such substances, the lack of which does produce certain abnormal conditions, but there has been a great temptation, especially in commercial quarters, to give the vitamin hypothesis undue prominence, and to assume that many conditions of ill being are dependent upon lack of vitamin in the diet.

As regards infant feeding, we have in this part of the world, for practical purposes, only the fat-soluble "A" and water-soluble "C" to consider, as beriberi (caused by a lack of water-soluble "B") occurs only in Eastern countries.

It is quite conceivable that an infant or a child could receive in its diet too small an amount of fat-soluble "A." If the diet were fat free and vegetable free he would receive little of it, as it is contained in only very small quantities in fat-free milk. Or if the cows from which the milk came were fed on vitamin-poor diets, as they often are in the winter, their milk would in all likelihood contain but small quantities of the vitamin. With breast feeding, likewise, the breast milk would be poor in this factor if the mother did not take sufficient quantities of butter

fat or of green vegetables. It is known, however, from clinical experience that it is possible to feed a baby on a practically fat-free diet over a long period of time without any apparent ill results, and it is probable that in the vast majority of instances breast milk or cow's milk even after it has been skimmed contains enough of the fat-soluble factor to prevent any untoward results. In times of famine, however, epidemics of xerophthalmia have been noted among children, and in the post-war German medical literature there are a number of papers describing the ill effects of lack of fat in the diets of Austrian children. The relation of the fat-soluble vitamin to rickets has not yet been settled, but there is evidence to show that it may have something to do with it, although not the essential cause.

Most of the experimental work on the fat-soluble vitamin has been done with animals, and we have not at present sufficient knowledge as to how often it is lacking in the dietaries of infants and children, or what the exact effect of such lack may be.

As a summary it may be said, however, that the experimental work on animals points the way, and that it can do no harm, and in all likelihood some good, for us to see to it that infants and children under our care receive an adequate amount of this accessory food factor.

Water-soluble "C" (The Antiscorbutic Vitamin).—From a practical point of view this is the most important vitamin concerned in infant feeding, as it is well established that a lack of it in the diet causes scurvy, which is not at all an uncommon condition. This will be discussed more completely in the chapter on Scurvy.

It is probable that the diseases xerophthalmia, beriberi, and scurvy, caused respectively by a lack of fat-soluble "A," water-soluble "B" and "C," represent the final pathologic condition brought about by a prolonged dietary deficiency, and that the earlier effect is manifested simply by general poor growth and nutritional state. Therefore, although xerophthalmia, beriberi, or scurvy may not be actually present, it may be possible that an undernourished child whose eating habits are peculiar may be

suffering from vitamin deficiency, and it is thus advisable that all children as soon as they are old enough to take a mixed diet should have an adequate supply of milk, fresh vegetables, and fruit or fruit juices, which will supply in abundance the three vitamins.

ENERGY REQUIREMENTS

The caloric requirements of infants has been the subject of extensive study, with somewhat varying results. Food is looked upon as fuel, and is measured in terms of calories or heat units; the caloric requirements represent simply the number of heat units per unit of body weight which it is necessary for the individual to ingest in order to thrive.

The calorie used in infant feeding is the large calorie, and represents the amount of heat necessary to raise 1000 c.c. of water 1° C.

One gram of fat furnishes 9.3 calories.
One gram of protein furnishes 4.1 calories.
One gram of carbohydrate furnishes 4.1 calories.

In calculating, the caloric requirements of infants and children must be taken into account:[1]

1. The basal requirement.
2. Growth needs.
3. Needs for muscular activity.
4. Food value lost in excreta.

The basal energy requirement represents that number of calories which is just sufficient to maintain life with the baby in complete repose, and is fairly constant in babies of the same weight. According to Morse and Talbot[2] normal babies have a basal metabolism of between 52 to 63 calories per kilogram of body weight. Very fat babies have between 40 to 50, and most infants who are underweight have more than 65 per kilogram.

The growth needs, the needs for muscular activity, and the food values lost in the excreta vary a great deal according to the baby. The growth needs of the infant during the first six months

[1] Holt and Fales, Amer. Jour. Dis. Chil., 1921, vol. 21.
[2] Diseases of Nutrition and Infant Feeding, New York, 1915.

are greater than at any other corresponding period, as this is the time of most rapid growth. The needs for muscular activity are of great importance, and vary in different babies, according to whether they are active or sluggish. The newborn baby uses up relatively little energy in this way on account of his comparative inactivity.

An unusually nervous, active baby needs more calories than a phlegmatic, inactive one, and Howland has shown that simply hard crying increased the heat elimination 18 per cent. in one infant and 39 per cent. in another.[1]

The food value lost in the excreta of course varies somewhat with different babies, but in general is fairly constant, and is not so important a variable as is the muscular activity and the rate of growth.

Heubner[2] was the first to use the term "energy quotient," and by it meant the number of calories per kilogram of body weight required per day. He estimated that the breast-fed baby needed in the first six months 100 calories per kilogram; that the artificially fed needed up to the third month 120, and that at the end of the first year from 70 to 80 was sufficient.

Beck[3] estimated that the energy quotient in breast-fed babies was as follows:

First three months, 107.
Second three months, 91.
Third three months, 83.
Fourth three months, 69.

The results for breast-fed babies according to various observers have been somewhat conflicting, and are probably not very accurate, because the amount of breast milk taken has been determined by weight, and a constant composition assumed for it, which is probably not justifiable.

Hoffman[4] found an energy quotient in breast-fed babies

[1] Howland, Amer. Jour. Dis. Chil., vol. 5, 1913, No. 5.
[2] Monatsch. f. Kinderh., 1904–5, iii, 206.
[3] Jahrb. f. Kinderh., 1910, lxxii, 121.
[4] Arch. f. Gynäkol., 106, 159, 1916.

(reckoning breast milk as 700 calories to the liter) of 113.8 for the first and second months, 96.5 for the third month, and 91.4 for the fourth month. In the first four months the average energy quotient was 107.4, in the second four months 87.4. Von Jaschke,[1] by careful daily determination of the amount of milk taken from the day of birth onward, assuming the liter of breast milk to contain 720 calories, found the following energy quotients:

Day.	Energy quotient.
1	9.8
2	17.9
3	24
4	41
5	60
6	72
7	88
8	108
9	114
10	119
12	103
21	122
56	110
75	102
90	104
98	105

As regards the energy quotient in artificially fed babies, the results of most observers are so conflicting, and their conclusions are so often founded upon inadequate data, that a summary of them would not be of value.

The most extensive and most accurate work on the caloric requirements of infants and children has been done by Benedict and Talbot, and reported in many publications. Holt and Fales,[2] with this work as a basis, to which they have added numerous observations of their own, have compiled what is probably the most accurate and useful tables of the caloric requirements of normal babies and children that have yet been published. These tables are reproduced on pages 72 and 73.

[1] Ztschr. f. Kinderh., vol. 16, June, 1917.
[2] Amer. Jour. Dis. Chil., vol. 21, 1921.

TABLE IV

Calories Per Kilo[1] for Boys

Weight, kilos.	Basal.	Growth.	Calories per kilo.			Total calories daily.
			Activity.	Excreta.	Total.	
3	46	56	8	10	120	360
4	50	52	8	10	120	480
5	54	46	8	10	118	590
6	56	38	10	10	114	685
7	57	32	11	10	110	770
8	56	28	12	10	106	850
9	56	25	12	10	102	920
10	54	22	13	10	99	990
11	53	19	14	10	96	1060
12	52	16	16	9	93	1120
13	51	14	17	9	91	1180
14	50	13	17	9	89	1240
15	49	12	17	9	87	1300
16	48	10	18	9	85	1360
17	47	9	19	8	83	1410
18	46	8	20	8	82	1470
19	45	7	21	8	81	1540
20	44	7	21	8	80	1600
22	42	7	23	8	80	1760
24	41	8	23	8	80	1920
26	39	8	25	8	80	2080
28	38	7	27	8	80	2240
30	36	7	29	8	80	2400
33	35	7	30	8	80	2640
36	33	8	31	8	80	2880
39	32	9	31	8	80	3120
42	31	10	31	8	80	3360
45	30	11	31	8	80	3600
48	30	11	31	8	80	3840
51	29	11	31	8	79	4030
54	29	8	31	8	76	4100
57	28	5	30	7	70	3990
60	27	2	27	7	62	3720
68 (Adult)	25	0	18	5	48	3265

[1] Kilo = 2.2 pounds.

TABLE V

CALORIES PER KILO[1] FOR GIRLS

Weight, kilos.	Basal.	Growth.	Calories per kilo.			Total calories daily.
			Activity.	Excreta.	Total.	
3	51	51	8	10	120	360
4	53	49	8	10	120	480
5	55	45	8	10	118	590
6	56	38	10	10	114	685
7	56	33	11	10	110	770
8	57	27	12	10	106	850
9	56	24	12	10	102	920
10	55	21	13	10	99	990
11	53	19	14	10	96	1060
12	51	17	16	9	93	1120
13	49	16	16	9	90	1170
14	47	14	17	9	87	1220
15	45	12	19	8	84	1260
16	44	11	19	8	82	1310
17	43	10	19	8	80	1360
18	42	9	19	8	78	1400
19	41	8	20	8	77	1460
20	40	7	21	8	76	1520
22	38	8	22	8	76	1670
24	37	8	23	8	76	1820
26	36	8	24	8	76	1980
28	36	8	25	8	77	2155
30	36	9	26	8	79	2370
33	35	10	27	8	80	2640
36	35	10	27	8	80	2880
39	35	10	27	8	80	3120
42	34	9	27	8	78	3275
45	34	7	26	7	74	3330
48	33	5	22	7	67	3215
51	32	3	21	6	62	3160
54	31	0	18	5	54	2915
60 (Adult)	25	0	15	4	44	2640

[1] Kilo = 2.2 pounds.

As regards abnormal babies, very fat babies need fewer calories than very thin ones; in general, the thinner the baby, the more

calories he needs. A very thin baby may need an energy quotient as high as 160 before he can begin to gain weight, and underweight babies in general, of whatever class, always need more than those of normal weight.

According to Dennett[1] the average needs of bottle-fed babies are as follows:

Fat infants over four months of age....	40 to 45 calories per pound per day.
Average infants under four months of age, and moderately thin babies of any age..........................	50 to 55 calories per pound per day.
Emaciated infants....................	60 to 65 calories per pound per day.

Ladd[2] found in a large series of poorly nourished infants that most of them did not make satisfactory gains in weight until the energy quotient was raised to 140 to 160, and sometimes as high as 175 or 190.

The practical conclusion to be drawn from all these figures is that theoretic caloric requirements are only a rough guide in the practical feeding of undernourished babies, and that the food must be pushed to the very limit of tolerance, irrespective of calories, until the baby begins to gain weight.

[1] Infant Feeding, 1920, p. 70.
[2] Arch. Ped., vol. xxix, No. 5, 1912.

CHAPTER II

THE STOOLS IN INFANCY

A KNOWLEDGE of how to interpret the stools is of the utmost importance in practical infant feeding, and the intelligent pediatrician should be able to reason backward from data obtained by stool examination, so that he can tell fairly accurately what processes are going on in the baby's intestine. The macroscopic examination is the most important, but in many cases microscopic examination also adds valuable data. While stool examination is important, the characteristics of the stools must not be taken by themselves in determining what to feed any given case, but must be considered in relation to the gain in weight, general condition of the baby, history, etc.

Let us take up the discussion of stools in the following order:

1. General characteristics.
2. Fat in the stools—its amount, form, and significance.
3. Sugar and starch.
4. Protein.
5. Miscellaneous.

General Characteristics.—*Number per Day.*—The number of stools passed in twenty-four hours varies considerably with the individual baby and the sort of food that he is taking. The average breast-fed baby has, as a rule, more stools than the normal bottle-fed baby. The breast baby has ordinarily from one to three stools a day, but in certain cases may have as many as six or seven and still do perfectly well. This would be impossible in a bottle baby. The number of stools a normal bottle-fed baby has depends a good deal upon what sort of food he is taking. If he is taking a formula containing a good deal of maltose he will have usually three or four stools a day, or the same number may result if he is taking a food high in sugar and fat

and low in protein. This is due to the stimulating action of the fatty acids formed from sugar and fat decomposition on intestinal peristalsis. If a food low in sugar and high in protein is fed the number of stools will be considerably diminished, and he will have only one or two a day, or one every other day. Bottle-fed babies ordinarily have fewer stools than those fed on the breast because breast milk contains so much more sugar and fat than most cow's milk modifications do, and, moreover, the casein and calcium of cow's milk tend to be constipating. If there is anything irritating in the intestine, increased peristalsis and an increased number of stools result. This may be brought about by nervous influences, but almost always is due to undigested or fermented food products or to actual infection of the intestinal wall by bacteria.

In general, it may be said that any number of stools over four per day is abnormal for a bottle-fed baby.

Form and Consistency.—The stools of a breast baby are rarely formed, and resemble thick porridge in consistency. They are rarely smooth, and may normally contain small white fat curds and small amounts of mucus. The normal stools of a bottle-fed baby are usually formed and are smooth and homogeneous; they should contain no curds, and none but the very smallest quantity of mucus. They may vary a great deal in consistency; in general, those babies who are fed on high casein and low sugar will have rather hard, dry stools, while those on high sugar and fat feeding are likely to have softer stools, which are not so well formed as those of the former type. If the baby's absorptive power is very good and if he is thus absorbing most of the food he takes in, the stools may have to stay in the colon and rectum for a considerable period of time before enough is collected to be evacuated; therefore the stool becomes hard and scybalous from loss of water. Skimmed milk and buttermilk stools are usually very smooth and shiny when spread out with a throat stick; if fat is added, they remain smooth, but lose their shiny character.

Odor.—The stools of babies fed on a milk diet rarely are very offensive. Those of the breast-fed baby have an aromatic acid

odor, while those of the bottle baby usually have a cheesy, slightly foul odor. If a high sugar and fat is fed, however, the odor is likely to be slightly acid, even in the normal bottle baby. With sugar and fat fermentation the odor is always acid (acetic and butyric acids), with a diarrhea caused by protein putrefaction the odor is foul. If the baby is being fed a large amount of starch which he is not digesting well, and which is fermenting in his intestine, the odor may be very offensive, like that of a pig-pen. The odor of ammonia is often noticed in connection with high protein stools, but may in a good many cases be due actually to ammonia on the diaper from an alkaline, concentrated urine, rather than to the stool.

Color.—The color of the breast baby's stool is golden yellow, or may sometimes normally be greenish. The color of a bottle baby's stool depends upon what sort of food he is being fed, and whether or not he has indigestion.

The color is usually a rather light yellow or yellowish brown. If a considerable amount of fat is fed it will be lighter, and if high fats plus high sugars are fed it is likely to be a brighter yellow. With high fat and casein and low sugar it is grayish, sometimes almost white. Skimmed milk mixtures high in protein give a stool of light gray or grayish-brown color, of smooth shiny consistency when smoothed out with a throat stick.

The stools of diarrhea due to protein putrefaction are brown. Adding a malt soup preparation to the diet gives a brown color similar to that of the original malt soup; starch in the diet also tends to cause a brownish color. Beef juice if added to the diet in sufficient quantities gives a dark brown color. Bismuth and iron give a grayish-black color. Argyrol when put in a baby's nose usually comes out in the stools unchanged in color and may cause a good deal of worry to the mother. Blood coming from the stomach gives a rich dark black color (tarry stool), while blood from the intestine gives a dark brick-red color if digested, or if not digested may appear in small bright red streaks. Blood on the outside of a constipated stool usually simply means that the rectum has been irritated somewhat by the progress of the

hard stool. Green is the most common abnormal color, and is seen in cases where there is fat, or more particularly sugar fermentation going on. A stool which is yellow when passed, but which turns green on standing in the air, is not abnormal. The green color is caused by the oxidization in the air of the bile-pigments. Stools which are green when passed are always abnormal. The explanation of the green color so commonly seen is as follows (Hecht):

Normally in stools there is hydrobilirubin (from the bile-pigments). This arises from bilirubin by reduction under the influence of intestinal decomposition, from the ileocecal valve onward. If the reduction processes are particularly active then the reduction of hydrobilirubin follows still a step further, to the colorless leukohydrobilirubin. If peristalsis is increased, so that there is no time for reduction, then the oxidation product of bilirubin (green biliverdin) is found in the stool.

Reaction.—The reaction of the stools is of great practical importance in infant feeding. As we have said before several times, there are always two opposing processes going on in the infant's intestine—fermentation of carbohydrate and putrefaction of protein. The breaking down of carbohydrate gives rise to acid end-products, with acid intestinal contents; the breaking down of protein gives alkaline end-products. There should be in the normal baby's intestine a certain balance between the two—that is, there should not be excessive fermentation or excessive putrefaction. Any baby fed on a milk containing a large amount of protein and but little carbohydrate will have alkaline stools, any baby fed on a high fat and sugar with little protein will have acid stools. Both of these conditions are normal, provided, however, that the alkalinity or acidity does not reach an excessive degree. If too much fermentation of carbohydrate or fat or too much putrefaction of protein takes place, the reaction becomes too acid or alkaline and trouble in the form of diarrhea results, due to too great a concentration of irritating alkaline or acid end-products. Excessively acid stools of abnormal consistency and appearance mean, then, that sugar or possibly fat

is not being taken care of; excessively alkaline stools mean that protein is being putrefied. In a few cases of sugar fermentation where there is a great deal of mucus present it may be possible to have neutral or alkaline stools, owing to the fact that the decomposition products of mucus are alkaline in character and may neutralize the original acidity. The breast baby has, it is true, very acid stools, of a degree of acidity which would be quite abnormal for the bottle baby. The probable reason why this excess acidity does not harm the breast baby is that it is mostly in the large intestine, whereas in the bottle-fed baby the excess acidity is usually in the small intestine where the delicately adjusted digestive processes are taking place. What bearing has all this on practical infant feeding? A good deal. If a strongly acid, normal appearing stool is seen, it means that it is not safe to add any more sugar to the diet, and if anything is added it should be protein or possibly starch, as the acidity shows that the baby is approaching the limit of his sugar tolerance. If an abnormal appearing, strongly acid stool is seen, it means that the limit of sugar tolerance has been exceeded, and that the sugar in the diet must be reduced or a change must be made to a sugar which does not ferment so easily.

The normal appearing, alkaline stool is the type that we like to see. This tells us that there is a mild putrefaction going on in the intestine (the normal condition when cow's milk is fed) and that if for any reason we desire to add sugar to the diet it is perfectly safe to do so, as the stool is alkaline, and there is a wide margin of safety. An abnormal appearing alkaline stool means that too much protein is being decomposed, and a decrease in the amount of protein and increase in the sugar is indicated.

These conceptions help me a great deal every day in my practical feeding work. The foregoing can perhaps be more clearly expressed in the form of a diagram.

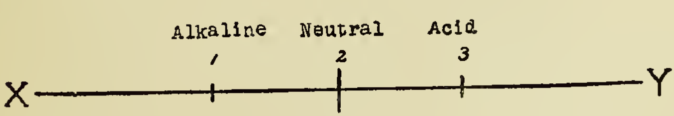


Fig. 1.

The reaction of the normal stool is at 1, 2, or 3, and if the amount of acid or alkaline decomposition products in the intestine does not get too far away from the neutral point, over to the extreme limits of X and Y, the baby gets along well; if the reaction becomes excessively acid or alkaline, he gets into trouble.

The reaction is easily determined by little pieces of red or of blue litmus-paper, or, after a certain amount of practice, by the smell of the stool.

Fat in the Stools (See Section on Metabolism of Fat).—A considerable amount of fat occurs in the stools normally, and in cases of fat indigestion this may be markedly increased.

(*a*) *Macroscopic Examination.*—The macroscopic appearance of the stools is often suggestive of an excessive fat content. Stools of four different sorts containing an excess of fat may be seen.

THE SOAPY STOOL.—This is a large, dry, crumbly, light colored stool, which contains a large excess of insoluble calcium soaps. Its reaction is usually alkaline, and it is seen in babies who are being fed on a fairly high fat, low sugar, and high protein. It is evidence of fat fed in improper relationship to the other food elements, rather than of a disturbance caused by fat *per se.*

THE "SCRAMBLED EGG" STOOL.—This stool is loose, of the consistency of thin scrambled eggs, and is strongly acid in reaction. It contains many small white, fat curds, and usually excoriates the buttocks, due to excessive acidity. It contains a large amount of fat partly in the form of soaps, but especially as fatty acids. It is usually seen in babies who are being fed on a high sugar and fat diet.

THE OILY STOOL.—This stool is usually bright yellow or sometimes yellowish-gray in color. It looks greasy, and if placed on a piece of paper leaves a transparent oil stain. It is usually of the consistency of thick cornmeal mush, and contains a large excess of neutral fat and fatty acid. The occurrence of this type of stool means almost always that the baby is being

grossly overfed with fat, and more neutral fat (entirely undigested) is seen in it than in any other type of stool except those of severe diarrhea. There may be only two to four of these stools a day, or they may be more frequent (six to seven) and very loose (fat diarrhea).

The Normal Appearing Stool.—An excess of fat may be present in a stool which appears normal macroscopically, and is revealed only by the microscope.

Microscopic Examination.—The microscopic examination of the stools for fat is of value if interpreted correctly, but may lead to entirely erroneous conclusions if it is not. The usual mistake that beginners make is to disregard the clinical appearance of the baby, his weight and his well being, and to rush to the laboratory with a stool. If they see a little fat under the microscope, they immediately make a diagnosis of "fat indigestion," cut down or omit entirely the fat in the diet, and thus deprive the baby often unnecessarily of many valuable calories. This has led many men astray, and under such circumstances microscopic examination of the stools for fat does more harm than good. *It must be remembered that there is always in the normal stools of all babies taking any fat in their milk a considerable amount of fat.* According to Holt, Courtney, and Fales the dried stools of normal breast-fed babies contain on the average about 35 per cent. of fat, in bottle-fed babies 36 per cent.[1] The fat in the stools is in the form of neutral fat, fatty acids, and soaps; mostly soaps. Fatty acids and soaps represent fat which has been digested, but not absorbed, neutral fat represents fat which has not even been digested.

There are methods of microscopic stool examination which attempt to distinguish between all these three constituents and to determine approximately how much of each one of these is present. It is this which has created so much confusion in the minds of students, but from a clinical point of view is entirely unimportant and cannot be done accurately anyhow. What is important to determine is whether or not there is an excess of

[1] Amer. Jour. Dis. Chil., vol. 17, April and June, 1919.

neutral fat and of total fat (neutral fat, fatty acids, and soaps together). This is done as follows:

First Procedure.—A small portion of the stool is rubbed up with a little water on a glass slide until a thin, smooth paste is formed. A drop or two of an alcoholic solution of "soudan III" stain is then mixed with this, and the film spread thin so that the light will shine through it. The preparation is then examined under the microscope with the low power. Neutral fat stains in bright orange-red globules. It is abnormal for more than a very few stained globules to appear with this first procedure, and shows that an abnormal amount of fat is coming through entirely unsplit. It is not at all common to see any neutral fat in a stool unless it is a diarrheal one, as usually most of the excess fat is in the form of fatty acids and soaps. Neutral fat is seen especially in the stools of babies who are being grossly overfed with fat, or in diarrheal stools, where the intestinal contents has been hurried through so quickly that the fat has not had a chance to be split.

Second Procedure.—A drop or two of glacial acetic acid is added to the first preparation and mixed thoroughly with it. Then the slide is heated for a moment over the Bunsen burner. In this procedure the heat and acetic acid break down the soap and neutral fat which are present into fatty acid; this fatty acid when melted is in the form of globules, and takes the stain in the same way that the neutral fat did originally. Any fatty acid which may have been originally present is also melted, and takes the stain. By microscopic examination of the preparation after this second procedure a rough idea of the total fat content may thus be obtained. There are so many factors that enter into the composition of a stool that it is impossible to have any absolute standard for what is an excess and what is not. In the first place, a dry, concentrated stool is likely to contain more fat than one of thinner consistency, which contains more water. Also, practically always when there is a diarrhea of any sort there is likely to be a large amount of fat in the stool, owing to the fact that the increased intestinal peristalsis sweeps out

neutral fat, fatty acids, and soaps before they have had a chance to be digested or absorbed. So excess fat in a stool does not necessarily mean a primary fat indigestion. Again, if a baby were having only one stool a day of moderate size, his fat absorption might be quite normal even if the stool when examined microscopically showed a large amount of fat, whereas if there were three or four large stools a day containing the same proportion of fat, the fat absorption would be considerably decreased, and a fat indigestion would be indicated. Furthermore, as Grover[1] has pointed out, if a large amount of protein is being fed, and there is consequently in the stool a considerable protein residue, there will not appear to be as much fat in the stool as in one where less protein residue is present.

From a practical point of view the fat content of stools as determined by this method may be divided into three groups:

1. In almost any normal stool, after Procedure II, there will be seen a good many fat globules scattered through the microscopic field. These do not run together much, and it is obvious that most of the stool consists of something else than fat. This is normal, and does not indicate that any reduction of fat in the diet is necessary.

2. There is a larger amount of fat in the stool than there is in the stools of Group I, and the stained globules are scattered very thickly through the microscopic field. If the baby is doing well and gaining weight, without symptoms of indigestion, such a stool picture does not call for any interference. If the baby is not doing well, it is best to reduce the amount of fat in his diet.

3. In the third group after Procedure II almost the whole stool seems to turn to melted fat globules, and under the microscope they are crowded together so thickly that they take up the entire field. Such an excess as this is usually seen in hard, dry, crumbly, light colored, "soapy" stools, or in oily, greasy stools, and practically always means that a reduction of the fat intake is indicated.

The only possible way that anyone can learn to interpret the

[1] Jour. Amer. Med. Assoc., vol. 6, No. 6, February 5, 1921.

fat content of stools is by examining a great many of them, and by comparing their content in fat carefully with the condition of the baby, the composition of his food, and the macroscopic character of the stool. The procedure is an art rather than an exact science, and each individual after practice establishes his own standards. Properly used, it gives information of considerable value in handling the case.

Older Children.—With older children on a mixed diet there is not so much fat in the stools as there is with smaller babies; therefore what might be quite normal for a baby would be abnormal for a child of two or three years. A considerable amount of fat in the stools is, therefore, of more importance in the case of an older child than it is in a baby. Babies under two months old almost always have a large amount of fat in the stools, even if they are doing well.

Sugar and Starch.—*Sugar.*—The stools of a baby who is utilizing sugar normally contain no sugar, as the absorption is nearly 100 per cent. If for any reason the absorption is poor, the unabsorbed sugar undergoes fermentation, and the acids which have been formed appear in the stools, giving the characteristic sour smell and acid reaction. In a very few cases unaltered sugar may be demonstrated in the stools, but this is by no means usually the case, and most investigators have reported negative findings. We do not, therefore, test directly for sugar in the stools, but depend upon the recognition of its decomposition products to determine whether or not it is being well utilized. It is probably not possible to have sugar indigestion without some sugar fermentation, and the type of stool depends largely upon the amount of undigested sugar that is being fermented. The stools of mild sugar indigestion are loose in consistency, usually yellowish-green in color, in number three or four per day, smelling strongly of acetic acid, and containing a good many small fat curds. They react strongly acid to litmus. In more severe sugar indigestion they are more frequent, watery, of a light or dark green color, strongly acid in reaction, and usually contain a good deal of mucus. They also

may contain fat curds or even casein curds, which have been hurried through the intestine too fast to be absorbed. Microscopic examination for fat in stools such as this is of no value, as they always contain large quantities of fat if the baby is taking an appreciable amount in his food. The macroscopic appearance, the smell, and the reaction are the important things to consider in the stools of sugar indigestion.

Starch.—Normally, there is only a very small amount of starch in the stool.

Starchy stools may be of two types:

The Fermented Starch Stool.—This is the most common type of stool seen in starch indigestion. It is large in size, of mushy consistency, of very offensive odor, either foul or resembling the sour smell of a pigpen. The end-products of starch fermentation are acid in reaction, but the reaction of these stools may be either acid or alkaline, depending upon the degree of fermentation, the amount of mucus present, and the amount of protein food which is being taken. These last two factors tend to give an alkaline reaction. These stools are usually olive green or brownish in color, are not homogeneous, and usually contain many small macroscopic masses of undigested starch and cellulose, which may be of a mucilaginous consistency.

Microscopically they show a large amount of undigested starch, either in the form of broken up granules or whole starch globules. Also many large iodophilic bacteria and yeasts are likely to be seen in any starchy stool.

The Unfermented Starch Stool.—In the fermented starch stool there has been a poor digestion of starch, and the undigested residue has undergone fermentation, with the production of irritating and offensively smelling substances. In the unfermented starchy stool there has been, it is true, an inadequate digestion and absorption of starch, but the unabsorbed residue has not fermented. These stools are large in size, usually brown in color, alkaline, rather smooth in consistency, of moderately foul odor, and have much the appearance of normal stools. Microscopically, however, they show a large amount of undigested

starch, which would never have been expected were it not for the microscopic examination. The children with this type of stool may seem well, and may show no symptoms of indigestion. It is probable that if fermentation does not take place the presence of undigested starch does little actual harm, but it is an indication that the amount of starch taken is more than the child can digest, and there is no telling when it may start to ferment and do him considerable harm.

Technic of Microscopic Examination for Starch.—To a small portion of stool rubbed up with a little water on a glass slide a drop or two of Lugol's solution is added (iodin 2, KI. 14, water 100). If there is much starch present this turns a dark blue or black color, and when examined under the microscope many black masses of undigested starch are seen. If the starchy part of the food intake has been thoroughly cooked the starch in the stool will appear as small masses of irregular shape and size; if the food has not been thoroughly cooked so that the starch granules have not been broken down, characteristic round or oval unbroken starch granules are seen. Different sorts of starches have different granules, and by careful examination one may often determine exactly what kind of starch is not being digested (oatmeal, barley, vegetable starch, etc.). Granules or masses which stain a purplish-red color represent starch which has been partly dextrinized by the processes of digestion. Undigested cellulose does not take the blue color with Lugol's solution, but is stained a light brown. If it has been partly broken down by the intestinal bacteria, which is often the case, it stains a light blue or a violet.

Protein.—As we have said before, the feeding of a high protein percentage in connection with a low fat and sugar produces, if the protein is well digested, a smooth, yellowish-brown or grayish-brown, alkaline stool, of rather cheesy odor. This appears shiny and glistening when smoothed out with a throat stick. Lactic acid, buttermilk, and skimmed milk stools are of this type, and are called normal "high protein" stools. Abnormal protein stools may be divided into two groups:

Those with casein curds.

Those in which there is excessive putrefaction of protein.

Casein curds are small, smooth, bean-shaped, yellowish-white masses. They range from the size of an ordinary baked bean to that of a large lima bean. They are tough and leathery in consistency, sink in water, and do not dissolve in ether. They can be confused with nothing else after one has once become familiar with their appearance. They do not look anything like fat curds, and if one has once seen a fat and a casein curd side by side he will never have any difficulty in distinguishing them thereafter. Casein curds do not ordinarily occur in the stools if anything has been done to the milk to modify the coagulation of casein, such as the addition of an alkali, boiling, peptonization, or treating with the lactic acid bacillus. Undigested casein may also sometimes appear as small indeterminate brownish-yellow masses of thick, gluey consistency. The exact significance of casein curds is in some dispute. A stool which contains them certainly cannot be considered normal, but it is a question whether they do much harm or represent a severe digestive disturbance. They act more as foreign bodies than in any other way, and represent a non-digestion of a certain portion of casein, without the addition of any bacterial decomposition. They may occur in stools of almost any color or consistency.

Putrefaction of Protein.—If there is an excessive putrefaction of protein in the intestine the stools become increased in number, loose in consistency, brownish in color, foul in odor, and alkaline in reaction. This type of stool is quite different usually from the casein curd stool; in the former we have a non-digestion of casein, without any extensive bacterial putrefaction; in the latter we have a non-digestion of protein with added bacterial putrefaction. Such stools as this usually indicate a more severe disturbance of digestion than do those of the first type.

Miscellaneous.—*The Starvation Stool.*—This type of stool occurs when the baby is being actually starved or is taking a weak cereal water preparation. It naturally contains very little food residue, and is made up of intestinal secretions, bac-

teria, mucus, and bile. It is usually alkaline in reaction, rather dark brown or greenish-brown in color, foul in smell, and sticky and loose in consistency. A common mistake is to confuse it with the stools of indigestion, and to continue the starvation, when, in reality, more food is needed.

Test For the Gas Bacillus.—Most of the procedures involved in bacteriologic examination of the stools are too complicated for clinical use. There is one organism, however, which may be of considerable importance in diarrheal diseases and in chronic indigestions. This is the gas bacillus, the significance of which has caused a good deal of controversy. It is true that it may occur in the stools of normal babies; it is also true that it sometimes occurs in the stools of babies with diarrhea, and seems to be the cause of the disturbance, as the diarrhea improves as soon as the gas bacillus infection has been overcome, usually by the employment of a milk containing large numbers of lactic acid bacilli, which are directly antagonistic to the gas bacillus.

The technic of the gas bacillus test used at the Children's Hospital is as follows:

1. Fill a U-shaped fermentation tube and a test-tube with concentrated nitric acid, let stand three minutes, and empty out the nitric acid.

2. Rinse both tubes with hot tap-water until neutral to litmus-paper.

3. Place a small bit of stool, about a gram of dextrimaltose, and about 15 c.c. of hot tap-water in the test-tube, and boil vigorously for half a minute.

4. Put the contents of the test-tube into the fermentation tube, taking care that it is filled up to the top, and that no air-bubbles remain in it.

5. Plug the tube with flamed cotton and incubate for twenty-four hours.

Gas in the top of the tube indicates that the gas bacillus is present in greater or lesser numbers, depending upon the amount of gas present. Less than one inch of gas in the tube is probably of no significance.

Bile.—It is occasionally of importance to test for bile in the stool. Rub up a small portion of stool in a mortar or evaporating dish, with a concentrated solution of corrosive sublimate, and let it stand for three hours. A brick-red color indicates that bile is present.

CHAPTER III

HUMAN MILK

Colostrum.—The breast does not begin to secrete milk immediately after parturition. For the first few days there is a scanty secretion of a slimy, yellowish fluid—the colostrum. The amount of colostrum is not large, the following figures being given by Von Jaschke:[1]

First day, 2 c.c.

Second day, 6 c.c.

Third day, 10 c.c.

The composition of colostrum seems to vary considerably according to the figures given by various observers:

	Fat.	Sugar.	Protein.	Salts.
Holt, Courtney, and Fales[2]	2.83	7.59	2.25	0.30
Pfeiffer[3]	2.17	3.5	6.45	0.34
Adriance[3]	3.77	5.39	3.31	0.27

It is certain, despite the rather wide variations in the above table, that it is relatively low in fat and sugar, and high in protein and salts. A considerable amount of the protein is in the form of globulin, which causes colostrum to coagulate when heated.

According to Courtney the composition of the ash as contrasted with the ash of mature milk is as follows:

	Total ash, per cent.	CaO.	MgO.	P_2O_5.	No_2O.	H_2O.	Cl.
Colostrum	0.30	0.044	0.010	0.041	0.045	0.093	0.056
Mature milk	0.20	0.045	0.007	0.034	0.034	0.060	0.035

[1] Ztschr. f. Kinderh., vol. 16, June, 1911.

[2] Amer. Jour. Dis. Chil., vol. 10, No. 4, 1915.

[3] Czerny and Keller, Des Kindes Ernährung, Leipzig, 1906.

Colostrum is especially characterized by containing numerous large leukocyte-like bodies, the "colostrum corpuscles," which contain many fat-droplets within the protoplasm, and which give to the colostrum its characteristic yellow color. The smaller corpuscles are probably leukocytes, according to Czerny, the larger ones large mononuclear cells. They may appear in mature milk if for any reason nursing has been interrupted, milk is allowed to collect in the breast, and there is consequently a diminished milk secretion. They disappear again as soon as nursing is resumed.

"Coming In" of the Milk.—The true breast milk "comes in" usually anywhere from forty-eight to ninety-six hours postpartum, but in some cases may be delayed considerably longer. It may come in gradually, so that the mother does not notice it, or it may, on the other hand, come in more suddenly, so that she can feel her breasts filling hour by hour.

Dluski,[1] in 326 primiparæ, found that the time of coming in of the milk was as follows:

9 times,	24 to 48 hours.
115 times,	48 to 72 hours.
159 times,	72 to 96 hours.
42 times,	96 to 120 hours.
1 time,	120 to 144 hours.

Physical Properties of Human Milk.—The specific gravity is from 1030 to 1032. The color is similar to that of cow's milk; the taste is a little sweeter, owing to the larger amount of milk-sugar that it contains. In certain cases the colostrum may be much more yellow than usual, and this yellow color may persist for a considerable period after the colostrum stage has passed. Very yellow milks of this nature do not ordinarily agree with babies, and in the few cases of mothers with bright yellow milk that I have seen the baby has usually been troubled a good deal with vomiting. The pigment is contained in the fat, accord-

[1] Thèse de Paris, 1894 (quoted by Morse and Talbot, Diseases of Nutrition, etc.).

ing to Palmer and Eckles,[1] and is the same pigment that there is in normal colostrum except that it is present in a more concentrated form. It consists of a mixture of carotin and xanthophyll, and is closely allied to vegetable carotin. It is derived especially from the chlorophyll in green vegetables, but may also be present in such vegetables as carrots, beets, and yellow corn. It is well, therefore, in any case where the milk is much more yellow than normal, and seems to upset the baby, to omit all green fruits and vegetables from the diet for a few days. It is in the first few weeks of lactation that this excessive yellow pigmentation is most likely to be observed.

Amount.—Nature has apparently not intended that the infant should receive much food in the first few days, therefore the amount of milk produced during the first week is not large. It increases gradually up to a certain point, as the baby's digestive powers develop, and then the amount remains more or less stationary during the rest of lactation.

The following table, by von Jaschke,[2] shows the amount of breast milk that a normal breast-fed baby received on various days during the period of lactation:

	Day.	Amount.
Colostrum period	First	2.5 c.c.
	Second	6.0 c.c.
	Third	10.5 c.c.
	Fourth	19.5 c.c.
	Fifth	300 c.c.
	Sixth	360 c.c.
	Seventh	440 c.c.
	Fifteenth	570 c.c.
	Twentieth	720 c.c.
	Thirty-seventh	805 c.c.
	Seventy-second	825 c.c.
	Eighty-seventh	925 c.c.
	Ninety-second	950 c.c.

By putting several babies to the breast, and thus furnishing a considerable extra stimulus, it is possible sometimes to greatly

[1] Jour. Biol. Chem., vol. xvii, 1914.
[2] Loc. cit.

increase the amount of milk. Sommerfeld[1] cites a wet-nurse of Finkelstein's whose daily average in the twenty-fifth month of lactation was 1700 c.c., and cases are on record where as much as 3 liters a day have been produced over a considerable period of time. The amount of milk produced is ordinarily between one-sixth and one-quarter the weight of the baby after lactation has become well established. The amount taken at each feeding varies a good deal, but the twenty-four-hour quantity remains fairly constant. According to Engel[2] the largest amount is always given at the first feeding in the morning, and tends to decrease as the day progresses. It is a commonly observed fact that in many cases when the supply of milk is not enough for the baby, this scantiness shows itself first by signs of hunger on the part of the baby after the 6 or 9 P. M. feeding.

Galactogogues.—"An artificial enrichment of milk secretion is not possible, and can be brought about by no drug or preparation, no matter what name it may bear, no matter what recommendation it may hold" (Engel).

If there is one thing that pediatricians are agreed upon it is that there is no practical, satisfactory galactogogue, and that the best way of increasing milk production is by stimulation of the breast by vigorous and frequent nursing. Especially is it necessary, in order to have abundant milk production, that the breast be completely emptied at each feeding. It has been said that pituitrin increases the flow of milk; this increase is only temporary, however, and is followed later by a diminution. Cornell[3] in 1918 carried on an interesting series of observations with placental extract. To 100 mothers, just delivered, he fed 5 grains of a preparation of placental extract four times a day for three days. He observed also 70 control cases to whom no placental extract was given. He found that 87 per cent. of the babies whose mothers received placental extract began to gain on the fourth and fifth days, as against 69 per cent. whose mothers did not receive it. Also, 44 per cent. of the babies

[1] Handbuch der Milchkunde, Wiesbaden, 1909.

[2] Ibid. [3] Surg., Gyn., and Obstet., vol. xxvii, 1918.

whose mothers received it regained their birth weights before leaving the hospital, as against 24 per cent. of those whose mothers did not receive it. Such a piece of work is suggestive, but at the present time it is fair to say that we have no proved galactogogue.

The repute that malt liquor enjoys as a galactogogue is probably due more to the increased amount of fluid ingested than to any specific property.

Chemical Composition.—The reaction of human milk is amphoteric; acid to phenolphthalein, alkaline to litmus. The reason for this amphoteric reaction is that it contains both mono- and diphosphates. The first react as weak acids (acid to phenolphthalein), the latter as bases (alkaline to litmus).

The milk of all mammals contains the following substances in an aqueous medium:

Fat—in emulsion.
Casein and lactoglobulin—in suspension.
Lactalbumin, Sugar, Salts, Extractives } in solution.

The composition of human milk is usually given as

Fat	4.00 per cent.
Sugar	7.00 per cent.
Protein	1.25 per cent.
Salts	0.20 per cent.

The variations may be considerable, however, in the milks of different women, and a baby may thrive on a milk which is far different from the average composition. According to Schlossmann,[1] the variations may be within the following wide limits:

Fat	1.65— 9.46 per cent.
Sugar	5.2 —10.9 per cent.
Protein	0.56— 3.4 per cent.

[1] Ztschr. f. Physiol. Chemie, Bd. xxii, p. 5197.

Fat.—The fat is the one most likely to vary of all the food elements, and very high or very low percentages are not uncommon. Low fat precentages are often found in combination with high protein percentages. There does not seem to be any relation between the stage of lactation and the amount of fat present. There is much less fat in the milk at the beginning of a nursing (fore-milk) than at the end (strippings). The extreme variations in this respect observed by Denis and Talbot[1] were 0.66 per cent. fat in the first part of the nursing and 10 per cent. in the last part. There is usually, however, less than 4 per cent. difference, as can be seen from the figures below, taken from their table:

	Fore-milk.	Strippings.
Case 1	4.0 per cent. fat.	8.0 per cent. fat
Case 2	6.4 per cent. fat	16.0 per cent. fat
Case 3	2.4 per cent. fat	8.0 per cent. fat
Case 4	2.4 per cent. fat	3.8 per cent. fat
Case 5	2.5 per cent. fat	4.4 per cent. fat
Case 6	3.2 per cent. fat	6.6 per cent. fat
Case 7	1.5 per cent. fat	2.9 per cent. fat
Case 8	0.66 per cent. fat	10.0 per cent. fat

Sugar.—The average amount of lactose in 60 samples of milk examined by Talbot and Denis was 7.19 per cent. There is less variation of the lactose content than is the case with either the fat or protein. There is a general tendency for the concentration of lactose to increase throughout the period of lactation. During the first ten weeks of lactation two-thirds of the samples examined by Talbot and Denis contained less than 7 per cent. After the tenth week there were many samples containing as high as 8 per cent. The smallest percentage of lactose found after the colostrum period was 5.49 per cent.; the highest, 8.35 per cent.

Chemically the lactose in human milk is identical with that in cow's milk.

Protein.—According to Engel the protein in human milk averages 1.04 per cent., according to Courtney, 1.15 per cent.,

[1] Amer. Jour. Dis. Chil., vol. 18, No. 2, 1919.

according to Denis and Talbot it is usually over 1.5 per cent. up to the fourth week, and after the twelfth week averages below 1.2 per cent. There is a tendency for it to become low late in lactation, and it may be 1 per cent. or lower from the tenth month onward. The amount of protein in the fore-milk and strippings varies but little. The proteins of human milk fall into two groups:

1. Casein.
2. Lactalbumin and lactoglobulin.

Casein is a water-insoluble, phosphorus-containing protein. It is held in suspension in milk on account of its combination with calcium and on account of the reaction of the milk. If human milk is acidified or treated with rennin the casein is precipitated in fine delicate flakes.

Lactalbumin and lactoglobulin are water-soluble proteins which coagulate on heating. There has been a good deal of discussion as to the relative amounts of casein and lactalbumin (plus globulin) in human milk. According to most authorities the casein makes up about 40 to 45 per cent. of the total nitrogen in human milk, the albumin plus globulin from 35 to 40 per cent., and the various non-protein nitrogenous constituents the remaining 20 per cent. The amounts of the non-protein nitrogenous constituents is not inconsiderable, and according to Denis, Talbot, and Minot[1] approximate closely the amounts contained in blood.

NON-PROTEIN NITROGENOUS CONSTITUENTS OF HUMAN MILK (DENNIS, TALBOT, AND MINOT)

Total non-protein N	20 –37 mgm. per 100 c.c. milk
Urea N	8.3–16.0 mgm. per 100 c.c. milk
Amino N	3.0– 8.9 mgm. per 100 c.c. milk
Preformed creatinin N	1.0– 1.6 mgm. per 100 c.c. milk
Creatin N	1.9– 3.9 mgm. per 100 c.c. milk
Uric acid N	1.7– 4.4 mgm. per 100 c.c. milk

Caloric Value.—The caloric value of human milk is from 700 to 800 calories per liter.

[1] Jour. Biol. Chem., vol. xxxix, 1919.

Salts.—The following mineral elements are found in human milk:

Phosphorus	0.029–0.041 gm. P_2O_5	per 100 gm. milk
Calcium	0.042 CaO	per 100 gm. milk
Magnesium	0.0068 MgO	per 100 gm. milk
Sodium	0.016 Na_2O	per 100 gm. milk
Potassium	0.069 K_2O	per 100 gm. milk
Iron	0.0001–0.0004 Fe_2O_3	per 100 gm. milk
Sulphur	0.014	per 100 gm. milk

The phosphorus is present partly in inorganic, partly in organic form. The inorganic phosphorus is combined with calcium as calcium phosphate, the organic is mostly contained in the casein (about 40 per cent.).

The calcium content may show great variations, according to Bahrdt and Edelstein[1] from 0.03 to 0.08 per cent. There is a considerable diminution of calcium toward the end of the first year of lactation, which perhaps partly explains why some babies who have been fed exclusively on the breast too long become rachitic. Bahrdt and Edelstein found that in anemia of the mother and child the calcium of the milk was not diminished. They could not increase the calcium content of the milk by feeding a diet rich in calcium. The older figures for iron (4 to 5 mgm. per liter) were probably too high, and with improved methods of analysis it has been shown that the iron content of human milk is very meager, probably rarely over 1.6 mgm. per 100 c.c. of milk (0.0016 per cent.). Bahrdt and Edelstein were able to increase the iron in the milk of an anemic woman by giving iron as a therapeutic measure. Coincidently with this the hemoglobin percentage of her baby's blood, who was also anemic, was increased.

Citric Acid and Chlorids.—The citric acid content of human milk is 0.05 per cent., the chlorid content, 0.035 (Cl).

Biologic Substances.—Besides the constituents already mentioned human milk contains biologic substances which may be divided into two groups (Engel):

[1] Jahrb. f. Kinderh., lxxii, 1910.

1. The immune bodies, antitoxins, etc.
2. The ferments.

It is known that immunity can be conferred by the milk of the mother to the nursing infant, also that agglutinins may occur, and that the milk of a woman with typhoid fever may give the Widal reaction as well as the blood. It has been shown by Salge[1] that diphtheria antitoxin may pass into the milk of a woman who has received it. A number of different ferments, such as lipase, amylase, etc., are present in milk, and even to a greater extent in colostrum. They are of considerable theoretic interest, but of little practical significance as far as human milk is concerned.

Variation in Milk Elements Through Changes in Food.—It is possible to change the chemical nature of the fat in human milk by changes in the kinds of fat fed in the food, and it has been shown that when certain kinds of fat are fed they pass unchanged into the milk. The chemical characteristics of the other food elements cannot be changed by diet. To a certain extent it is possible to change the amounts of fat or of protein by increasing or diminishing the amount of the food intake or by exercise. The sugar varies but little. (See next chapter.)

Drugs in Milk.—According to Engel, the only drugs that have been shown with certainty to pass from the mother into the milk are potassium iodid, soda salicylate, aspirin, antipyrin, mercury, calomel, arsenic, and bromid. All of these, however, are present probably in only very small quantities, and it is doubtful if breast milk ever contains enough of any one of these drugs to do the baby any harm.

Bacteriology.—Staphylococcus albus and aureus may be found in the milk of healthy women and are of no pathologic significance. The probable explanation of their presence is that they have penetrated from the outside a short distance into the milk-ducts, and are washed out again in the stream of milk. In such conditions as mastitis, where there is infection of the breast itself, streptococci may appear in the milk, but

[1] Jahrb. f. Kinderh., Bd. 68, 1904.

most authors are agreed that ordinarily bacteria do not pass from the blood-stream to the milk. Lawrence,[1] however, found typhoid bacilli in the milk of a nursing mother who had typhoid fever. In a few cases it has been proved that tubercle bacilli may occur in the milk of tuberculous women even if the breast is not diseased, but this is the exception rather than the rule. In the vast majority of cases tubercle bacilli cannot be demonstrated in the milk of a tubercular woman.

[1] Boston Med. and Surg. Jour., clxi, 1909.

CHAPTER IV

BREAST FEEDING

Importance.—The importance of breast feeding cannot be overestimated. Despite the great improvements that have been made in artificial feeding in recent years, it is not easy to produce a baby by artificial feeding that can equal in any way a baby the product of successful breast feeding.

The following bare statistical facts collected by Davis[1] illustrate better than pages of argument or more numerous quotations the value of breast milk to the baby.

1. In Boston in 1911 there were 621 deaths from diarrheal diseases in babies under one year of age. Of these, 534 were bottle fed.

2. Of infants reaching the age of two weeks in Boston, 1 in 5 dies before it is one year old if bottle fed, while if breast fed, only 1 in 30 dies.

3. If all babies could be breast fed the deaths would be 60 per cent. less.

4. The actual number of infant deaths in Boston in 1911 was 2248. Breast feeding would have saved nearly a thousand of these, and the death-rate instead of being 127 per 1000 births would have been 71.

These figures are taken from but one city it is true, but similar figures hold for all cities of all nations. Many mothers, and, unfortunately, many doctors likewise, do not realize the importance of breast feeding, and the general tendency is to deprive the baby of the advantages of this on entirely insufficient grounds. It is, of course, true that some women cannot nurse their babies at all, but the number of these is not large, and the vast majority of all women can give their babies a start on the breast at any rate. It is in the first few weeks of life

[1] Amer. Jour. Dis. Chil., vol. 6, 1913, 1234.

that artificial feeding is most difficult and more likely to be unsuccessful than at any other time.

There are very few women at the present time who are unwilling to nurse their babies when they can. Rarely will such a woman be met with, even among the much maligned upper classes. If, after careful explanation of the advantages of breast feeding, the mother declines, without good reason, to nurse the baby, it is best to withdraw from the case entirely. In Manning's[1] series of 1000 cases from private practice there was only one mother who refused to nurse.

The following figures from this series show very well the average duration of nursing, and represent fairly closely, I believe, the situation among the better classes in the average community:

Duration of nursing.	Per cent.	Duration of nursing.	Per cent.
1 week	8.1	13 months	1.7
2 weeks	1.8	14 months	1.0
3 weeks	4.0	15 months	0.8
1 month	4.9	16 months	0.4
3 months	7.9	17 months	0.2
4 months	9.2	18 months	0.9
5 months	6.8	19 months	0.1
6 months	5.5	20 months	0.1
7 months	4.7	21 months	0.1
8 months	4.2	22 months	0.1
9 months	7.5	22 months	0.1
10 months	4.5	30 months	0.1
11 months	3.0	36 months	0.1
12 months	6.1		

These figures make an interesting comparison with those of Mitchell,[2] whose statistics are drawn from the hospital class, and represent 2819 cases:

	Nursed not at all.	One week or more.	Three months or more.	Six months or more.	Nine months or more.	One year or more.	Eighteen months or more.	Two years or more.
Mitchell	20.0%	80.0%	55%	42%	34%	27.0%	9.0%	2.0%
Manning	8.1%	91.9%	64%	41%	26%	11.8%	1.6%	0.3%

[1] Arch. Ped., vol. xxxvii, No. 4, 1920.
[2] Amer. Jour. Obstet., 1912, lxvi.

Sedgwick[1] sent questionnaires in 1912 to a large number of doctors requesting information as to the ability of their wives to nurse. The results showed that about 80 per cent. of the wives of American physicians succeeded in nursing one or more children three months or longer.

The Nursing Mother.—Nursing a baby is a natural, physiologic process, and should not necessitate any great change or modification in a woman's habits provided she is leading a reasonable life already. A woman of even, quiet temperament usually makes the best nurser, and the unstable, nervous type of woman is likely to be unsuccessful. Women between the ages of twenty and thirty-five usually are able to feed their babies most successfully, but I have seen satisfactory nursing in women over forty. There seems to be no especial criterion by which to judge whether a woman will have an abundant supply of milk or not; other things being equal, a robust, strong woman is more likely to have good milk and plenty of it than a small, delicate woman; but many women in the pink of condition who lead the most healthy, athletic sort of lives have practically no milk, and others, who seem frail and ill fitted for motherhood, will have an abundant supply. The best nursing mother that I have ever seen in private practice weighed under 100 pounds, and nursed her baby without supplementary feeding, and without apparent detriment to herself, up to ten months, at which time the baby weighed 20 pounds.

A considerable amount of physical exercise, though not to the point of fatigue, is always advisable; and many nursing mothers during the first few months, especially if they take care of the baby themselves, do not get outdoors enough, and are likely to get into rather an unhealthy condition. Many women while in bed during the first few weeks have little milk, and this is often greatly increased after they get up and around. As an old Boston obstetrician used to say, a woman should be trained for the ordeal of labor just as an athlete is trained for a race. The same holds true of the nursing period, and the

[1] Jour. Amer. Med. Assoc., 1916, lxvi, p. 1690.

daily life and routine of a nursing woman should be as sane and as wholesome as possible. No woman, unless it is absolutely necessary for financial reasons, should attempt to do the housework and look after the baby into the bargain, whether the baby is breast or artificially fed. There is nothing that is more tiring than looking after a little baby day in and day out, and motherhood plus too heavy household cares is the cause of most of the wornout, young-old women that we all see so frequently. It is far better for a family to economize in some other way, and have a cook or a nurse girl. In these days this is often a real problem.

The nursing mother should eat a reasonable, well-balanced diet, the same as any normal woman would eat. She must naturally eat a little more of it when she is nursing a baby, as she is feeding two individuals instead of one. Particularly is it advisable for her to have a considerable amount of protein in her diet, but only a sufficient amount to cover her own protein needs, and that extra amount demanded by the milk. Hoobler[1] has shown that animal protein is more efficient than vegetable protein in supplying nitrogen for milk and for the maintenance of nitrogen balance. Cereals and other starchy foods, fruits, and vegetables are valuable foods in any well-balanced diet, but the diet should not be one-sided in this respect, as these articles do not furnish enough protein. The practice that some nursing women have of stuffing with all sorts of rich food in the belief that they will produce more milk in so doing rarely does any good.

There is no need of abstaining from green vegetables and acid fruits in the vast majority of cases, although many women have the idea that these are injurious to the baby. The best plan to follow is to let the mother eat anything she desires within reason, and then if any particular article is found to upset the baby, to omit this from the diet.

A considerable fluid intake is necessary for every nursing mother, although here, again, no extremes are necessary. Three

[1] Amer. Jour. Dis. Chil., vol. 14, 1917, No. 2.

pints of fluid daily is probably a sufficient quantity for most women. In most cases it is not possible to produce more milk by drinking more fluid. There are a few women, however, who seem to need large amounts of fluid in order to have a sufficient quantity of milk, and in a number of cases I have seen the milk supply become insufficient if they did not keep up this practice. The kind of fluid makes very little difference; plain water is just as good as cocoa, malted milk, or gruels, although the psychologic effect is probably rather important; a woman feels that she is accomplishing considerably more for her baby if she drinks 3 glasses of milk or of malted milk than would be the case with an equal amount of water.

Care of the Nipples.—It goes without saying that the nipples should be kept scrupulously clean. Small amounts of milk are likely to remain after the nursing or to run out between the nursings. This decomposes, and an uncared for nipple may be a very dirty article indeed. Dirty nipples are the most frequent cause of breast abscess. It is the common practice to wash the nipples with a saturated solution of boric acid before and after nursing. The boric acid certainly does no harm, but it is doubtful whether it does any good, as an antiseptic strong enough to kill the bacteria present would erode the nipple. Plain boiled water is probably as efficient a nipple wash as anything else, although I suppose if a physician ordered it instead of boric acid solution, and a breast abscess developed, he would probably be considered very careless. It is important to wipe the nipple dry after it has been washed, as it is likely to keep in a much more healthy condition when dry than if it is allowed to stay wet. Little pads of gauze should be kept in place over the nipples between nursings, and a firm breast binder is acceptable to many women, especially during the first few weeks. If the nipples are rough, they should be smeared with lanolin after each nursing.

Feeding in the First Few Days.—If the labor has been an ordinary one the baby can be put to the breast about twelve hours after delivery. The baby should be given as much water

as he will take before this, however. The common practice is to give sugar and water, or, as many of the books say, water sweetened with saccharin. Neither one of these practices has anything to recommend it; plain boiled water is just as good. Furthermore, a newborn baby does not need to have any food in the first few hours, and nature never intended that he should. By introducing sugar into the intestine at such an early time there is a possibility of interfering with the development of the natural bacterial flora, which was meant to develop upon colostrum and not upon sugar.

I believe it best to use three-hour intervals from the start, as the more the breast is stimulated, the more quickly is the milk likely to come in. If six- or four-hour intervals are used, the breast is naturally stimulated much less than with the three-hour intervals. Also, there is often some little difficulty in teaching a newborn baby how to suck, and the more often he practices, the quicker will he learn. The nursings should at first not be longer than five minutes, however, as the nipples are at first very tender. In the first three days the baby gets very little nourishment, and loses weight, partly as a consequence of this and partly from other causes (see Chapter I). The breast milk should be in normally by the third or fourth day, and if it is delayed longer than this it is best to start a weak artificial feeding given in small amounts after each breast feeding. The milk is often considerably delayed in coming into the breast, and breast feeding should never be discontinued on account of this. If the baby is rather small and weak, and does not nurse well, stimulation of the breasts as advocated by Sedgwick often seems to help a good deal in producing secretion, and it is certain that failure of breast feeding is often caused by insufficient stimulation of the breasts during the early days.

Directions for Milking (Sedgwick[1]).—"The breast is grasped about 1 or 2 cm. back of the colored areola, and a milking motion is carried out toward the nipples. No massage of the breast

[1] Jour. Amer. Med. Assoc., 64, p. 417, 1917.

proper is allowed, as it is of little if any value, and sometimes causes traumatic inflammatory reaction. If we consider the anatomy of the breast, we learn that the ducts which contain the milk extend but a short distance back of the areola. Any one who has ever seen a cow knows that the teats are milked and not the cow's bag, and yet we often find head nurses, physicians, and even pediatricians giving instructions to milk or 'massage' the breast itself. If our method is intelligently followed it is possible to keep the mother of a premature infant from losing her milk. I have seen some such mothers supply not only milk for their own baby but also enough for another infant."

The baby should usually stop losing weight at about the fourth day, and if he does not start to gain by this time it is best to keep on with the complemental feeding, as in this way much valuable time can be saved, and an excessive loss of weight can be prevented. This is rather important, as a too large loss of weight in the early days may be a severe handicap to a small baby. The chart (Fig. 2), taken from my case records, shows about what the weight of a normal newborn breast-fed baby can be expected to do in the first two weeks.

By the time the baby is two or three weeks old he should have regained his birth weight and should be gaining regularly.

A newborn baby usually passes meconium soon after birth, and continues to pass it until the milk comes in, after which the stools begin to take on the characteristic golden yellow color. If no meconium has been passed in the first twenty-four hours it is well to give $\frac{1}{2}$ teaspoonful of castor oil, as it is not uncommon for decomposing retained meconium to cause fever, and more rarely convulsions. In general, however, it is best to avoid the indiscriminate use of castor oil in newborns, and to give instructions to the nurse that it shall not be given, as many of them have a bad habit of giving castor oil every day, for just what reason I have never been able to find out.

Gain in Weight.—The best index of the well being of a baby, whether breast or bottle fed, is a steady and satisfactory gain in weight. A breast-fed baby should gain from 6 to 8 ounces

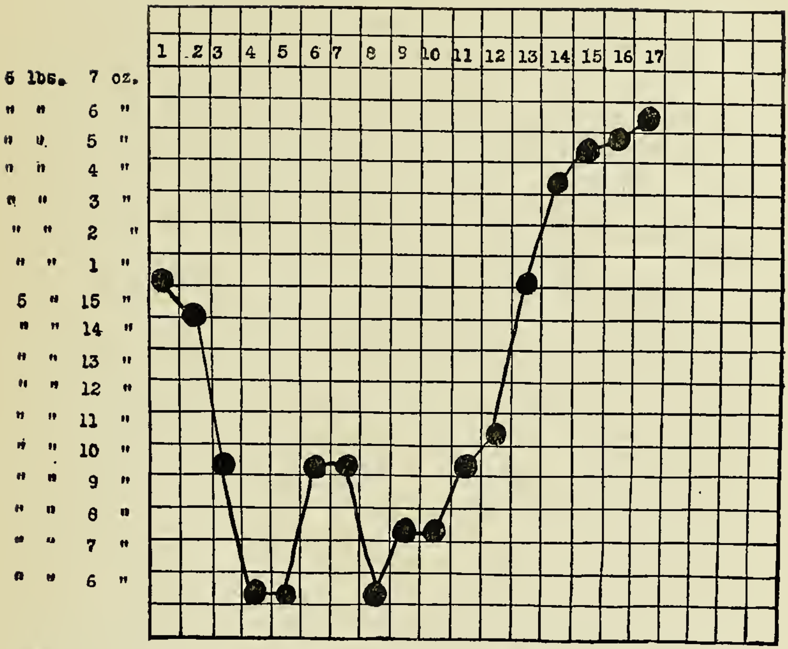


Fig. 2.—Baby W. Birth weight, 6 lbs. 1 oz. Loss, 11 oz. Lowest weight on fourth day. Birth weight regained on the thirteenth day.

BABY'S WEIGHT RECORD

WEIGHT OF BABY.................LBS...............OZS. AT BIRTH DATE.................................

DATE	AGE IN WEEKS	LBS.	OZS.	DATE	AGE IN WEEKS	LBS.	OZS.	DATE	AGE IN WEEKS	LBS.	OZS.	DATE	AGE IN WEEKS	LBS.	OZS.
	1				14				27				40		
	2				15				28				41		
	3				16				29				42		
	4				17				30				43		
	5				18				31				44		
	6				19				32				45		
	7				20				33				46		
	8				21				34				47		
	9				22				35				48		
	10				23				36				49		
	11				24				37				50		
	12				25				38				51		
	13				26				39				52		

Fig. 3.

a week during the first six months, and 4 to 5 ounces a week the next three months. Anything less than this is not satisfactory. Accurate weekly weighing is of the utmost importance, and it is often surprising to see how many otherwise intelligent doctors and mothers neglect this. It is very convenient to have little printed cards,[1] such as is shown in Fig. 3, to give to every new mother, so that she can have an accurate record which the doctor can scan at a glance to see how the baby is doing.

Plotting the baby's weight against a theoretic curve is a pernicious practice, as babies vary so much in their initial weights that often the mother is unnecessarily worried by the failure of the baby to follow the curve. Another pernicious practice after the first three weeks is to weigh the baby every day or so. No baby gains regularly every day, and may often lose several ounces, which he will gain back the next day. Daily weighing is one of the most potent sources of worry to a nervous mother.

Intervals of Nursing.—There is always much discussion concerning the correct nursing interval. With breast-fed babies the three-hour interval has seemed to me the most satisfactory in the vast majority of cases. Only in the case of very weak or premature babies, who take little at a feeding and do not nurse vigorously, is a more frequent nursing necessary. Many breast babies do very well on four-hour feedings, particularly if the baby is robust and the supply of milk abundant. Absolute regularity should be adhered to in the nursing hours; one cannot start to train a baby too soon, and it is the babies trained in regular habits of eating and sleeping who, as a rule, do best. Undoubtedly many breast-fed babies do well who are fed every time they cry, but these are the exception rather than the rule. One of the hardest things to teach dispensary patients is that regular nursing hours are better than irregular. A good start means a great deal to the baby, and to the peace of mind of his mother, and a really good obstetric nurse will

[1] These are kindly supplied me by E. F. Mahady Co., Boston.

do wonders in getting the daily routine running smoothly. Some writers believe that a baby should never be waked from sleep to nurse. The best answer to this is that as a great many small babies sleep most of the time, they would get very little to eat if this rule were adhered to. In my opinion a baby should *always* be waked to nurse. He will usually go to sleep again immediately afterward.

Amount at Each Feeding.—A baby rarely gets the same amount at each feeding during the course of the day, but the twenty-four-hour amount is likely to remain fairly constant. The supply of breast milk is usually most abundant in the morning and scantiest at the late afternoon and evening feedings. Most of the milk is obtained in the first five minutes of nursing, although the richest part of the contents of the breast, the "strippings," containing a high fat percentage, is not withdrawn until toward the end of the nursing. Most babies nurse about fifteen minutes as a rule. A few unusually strong, greedy babies will empty the breast in much less time than this, however, and a weak baby may remain at the breast for half an hour or more. In general, if the baby nurses over twenty minutes it indicates that the breast milk is scanty in amount, and that by keeping on nursing the baby is hoping against hope to squeeze out a few drops more.

Substitution of One Bottle Feeding.—It does no harm, and is indeed a good idea in many cases after the first month to substitute one bottle feeding for a breast feeding. This gives the mother a chance to get out and see her friends, and to get away from the baby for a while, which may be just what she needs. The usual feeding substituted is the 3 P. M. feeding. This leaves the mother free from 12 M. to 6 P. M.

Night Feedings.—There is no reason why a normal baby over a month old should be fed in the middle of the night, and it is always a good plan to have the baby broken of the 2 A. M. feeding as soon as possible. I have known this to be done in a good many cases before the mother and baby left the hospital, and I always try to have it accomplished by the obstetric nurse

before she leaves, so that the mother will not be bothered with it. The best plan to follow is to use a somewhat longer interval after the 6 P. M. feeding, making the last feeding at 10 or 10.30, being sure that the baby gets plenty, with the addition of a small complemental feeding if necessary. This may carry him through the night; if it does not, it is best to give a little water for a few nights, or to let him "cry it out." In these days the old idea of waking up every few minutes during the night to feed the baby is, or should be, obsolete.

Stools.—The stools of a breast-fed baby are usually two or four daily, golden yellow in color, mushy in consistency, and have an aromatic, sour smell. Variations may occur quite normally, however. A not inconsiderable number of perfectly normal breast-fed babies will have as many as six or seven green, curded stools daily, without any harm whatsoever. Other normal babies will have a stool only every other day. Mothers have it clearly fixed in their minds that a baby *must* move its bowels every day in order to be well. This is not so, and many well babies very frequently skip a day. If loose green stools or constipated stools are accompanied by symptoms of gas, vomiting, excoriated buttocks, etc., the condition is, of course, abnormal, and calls for treatment, but it is surprising to see how many breast-fed babies will have all during the nursing period five or six green, loose, curded stools a day and still gain regularly and do well.

Weaning.—In most cases a baby should not be allowed to nurse at the breast after the ninth month, and it is well to have him accustomed to the bottle before this time so that there will be no trouble with the weaning. The best way to wean is to gradually replace the breast feedings by the bottle, substituting a bottle feeding for a breast feeding every two or three days, until the baby is getting the breast only twice a day. When this stage has been reached he may be weaned entirely. In most cases there will be little difficulty with weaning, especially if he has been previously accustomed to the bottle or the spoon. In a few cases considerable difficulty is experienced,

owing to the fact that the baby will not take the bottle if he has any chance of getting the breast. If this difficulty arises the weaning must be abrupt and the breast milk dried up at once. After the baby has gone for a few feedings without anything to eat, and once he clearly understands that there is to be no more breast milk for him, it is usually plain sailing. It is best to have the mother out of sight when the bottle is given, until the baby becomes well accustomed to it. As soon as he is taking bottle milk well, cereal and soup or zwieback may be started, according to the principles of artificial feeding laid down in another chapter.

In hot climates during the summer, where the purity of the milk supply is uncertain, it is usually best not to wean during the hot weather. In places where the milk supply is good, and the weather is not excessively hot, weaning can be done at any time of the year.

The mother usually experiences little difficulty in drying up her breasts. Enough Epsom salts should be given each day to produce two or three watery movements, and she should take as little fluid as possible.

Difficulties Arising During Lactation.—*Depressed or Inverted Nipples.*—Not a few women have poor nipples. They may be either merely rather flat, and therefore difficult for the baby to take, or they may be actually inverted, and therefore prevent nursing entirely. The time to treat flat nipples is several months before the birth of the baby. The mother should be instructed to pull them out several times daily, and if she does this faithfully, they may become considerably elongated. With actually inverted nipples little can be done, and the use of a nipple shield is necessary. Some babies take nipple shields very well; others refuse them absolutely. In general, it has seemed to me that nipple shields are most unsatisfactory.

Cracked Nipples.—If care is taken, cracked nipples should not develop. The baby should take not only the nipple in his mouth but also a considerable area of the areola behind the

nipple. If this is done the nipple suffers less trauma. It is especially important to keep the nipples dry and to leave no decomposing milk on them. If they show a tendency to dryness and hardness, they can be smeared with a little lanolin after each nursing.

If fissures develop, the nursing may be extremely painful to the mother, often so much so that it becomes practically impossible. If cracked nipples could be left alone for a few days they would heal readily, but it is the continual irritation and pulling of the baby upon them that keeps the cracks open and prevents healing. The best plan to follow is, first of all, to try a nipple shield, and if this does not work, to remove the baby from the breast in question for several days, and feed him artificially, taking care, however, to empty the breast with a pump at regular intervals, in order to keep up the milk secretion. During the few days that the baby is not taking the breast applications of a 5 per cent. silver nitrate solution to the fissures has seemed to me to be the most efficient method of treatment. There is little use in trying to heal cracked nipples with the baby sucking at them every three or four hours; if he is fed otherwise, and the crack given a chance to heal, the condition usually clears up readily.

Caking of the Breast.—If there is a large amount of milk in the breast, particularly during the first few weeks of lactation, and the baby on account of feebleness or otherwise, does not empty it completely, caking is likely to occur. This is shown by the presence of hard, sometimes slightly tender lumps in the breast, particularly in the dependent portions. This should not be confused with mastitis. The treatment is to see that the breast is completely emptied after each nursing, with a breast-pump if necessary.

Mastitis and Abscess.—Mastitis means an actual inflammatory condition of the glandular tissue of the breast. The infection practically always gets in through the nipple, and is usually due to the staphylococcus. Cracked nipples and undue caking of the breast may be important causes. Any septic condition

of the baby may be also a cause. According to Norris, mastitis occurs in from 0.5 to 4 per cent. of all nursing mothers, particularly in the early weeks of lactation. It is very likely to start with a chill, and an abrupt rise of temperature to 101° or 102° F. The infected part of the breast is hot, red, and tender. The baby should at once be prohibited from nursing on the infected breast, although he may continue to nurse on the normal one in most cases, unless the mother is too sick. The object of treatment in mastitis is to prevent the condition from going over into actual abscess formation, and for this purpose the continued application of cold in the form of an ice-bag is the most efficient means. If a high temperature lasts for more than forty-eight hours it is probable that pus is present, and that surgical intervention will have to be resorted to. If in conjunction with the continued high temperature the mass in the breast increases in size, redness, and tenderness, and becomes fluctuant, it is certain that a breast abscess is present, the treatment of which is incision and drainage. After most cases of single mastitis the supply of milk on that side will be considerably diminished, but with a complementary feeding nursing at that breast may be continued. After abscess there will probably be no milk in the breast, and half-substitute feeding will have to be employed.

Acute Disease in the Mother.—When a nursing mother develops an acute infectious disease it is often a question of nice judgment whether the baby should continue nursing or not. Although it is undoubtedly possible in some cases for the baby to continue nursing during certain long-drawn-out febrile conditions in the mother, and although in the last few years a number of pediatricians have advocated the continuance of nursing during such diseases as typhoid fever and pneumonia, my personal feeling is that it is best to wean the baby if the mother is going to be sick more than a few days. Artificial feeding is so successful now compared to what it used to be that there is a good deal more danger of the baby's going wrong if nursing is continued than if he is weaned. Furthermore,

a really sick woman, with any febrile disease which is going to last for more than a few days, has need of all her energy, and has none to spare in feeding a baby. In such conditions as tonsillitis or uncomplicated influenza there is no need of weaning. In the longer infections, as I have said, it is generally best to discontinue nursing, although, of course, no hard-and-fast rules can be laid down, and each individual case has to be decided according to circumstances.

Pregnancy.—If a nursing mother becomes pregnant again the baby should in most cases be weaned. Here again, however, one must not be too dogmatic, for special circumstances may have to be considered. If the baby is a small one and needs breast milk, if it is during the very hot weather, if the baby is acutely sick or is recovering from some infectious disease, it is better to let nursing continue for a month or two. It is undoubtedly possible for some women to carry one baby *in utero* and nurse another; but, unless there are some special reasons to the contrary, the nursing baby should be weaned as soon as pregnancy has been recognized. In the South during the summer the question of weaning a baby on account of acute infection or pregnancy in the mother has to be regarded in a somewhat different light from what it is in the North. So many artificially fed babies die every summer in the South from the diarrheal diseases that breast feeding must never be discontinued at this season if it is humanly possible to continue it.

Menstruation.—Some women menstruate while nursing, some do not. It is a clinical fact that many babies are upset during the first day or two of menstruation. This is shown by fussiness, colic, green, loose stools, and sometimes vomiting. The cause of this is not clear. It is not unreasonable to suppose that there should be changes in the breast milk during menstruation, as the breasts and the uterus are intimately connected organs. There is much difference of opinion as to this, however. Czerny and Keller say that there is no chemical change in the breast milk during menstruation. Langstein and Meyer

believe that while there is no change in composition, there is a diminution of milk, which makes the baby fretful. This question has been investigated by Rantenga and Filippo.[1] They examined the breast milk of menstruating women, some of whose babies were upset by the menstruation, some not. They studied particularly the lactose and chlorid content, and found that the lactose and chlorids were normal in all cases where the baby was doing well (7.3–7.8 per cent. lactose—24–43 mgm. chlorids per 100 c.c. of milk). In another series of cases where the babies were restless and irritable, and were having loose green stools, they found a low lactose and a high chlorid content. The lactose ran as low as 4 per cent. and the chlorids as high as 168 mgm. per 100 c.c. of milk. This condition of the milk they found most likely to be present twenty-four hours before the onset of the menses. They also found that in all cases where the baby was upset the quantity of milk was decidedly less than normal. This is the first real light that has been shed on the subject. It is practically never necessary to wean a baby on account of menstruation of the mother. The upset lasts only a day or two in most cases, and if it should last longer than this, bottle feedings can be given and the breasts pumped until menstruation ceases.

Contraindications to Nursing.—Any chronic, wasting disease in the mother is a contraindication to nursing. Under this head come cancer, tuberculosis, chronic nephritis, secondary anemia or any other blood disease, hyperthyroidism and decompensated heart disease, and diseases of the nervous system. There is no particular reason why an epileptic should not nurse her baby if the attacks are infrequent and if the nursing seems to do her no harm. No woman with tuberculosis in any form ought to nurse her baby, as small babies are extremely susceptible to tuberculosis, and the baby will certainly get it if he is in close association with the mother. Syphilis, unless it takes such a form that the mother is feeble, on the other hand, is an indication for breast feeding rather than a contraindication,

[1] Ztschr. f. Kinderh., vol. 14, No. 182, 1916.

as if the mother is syphilitic, the baby probably is, and needs the very best food possible. Most women with neurasthenia are too nervous to nurse their babies. Women who have had eclampsia and who have been delivered prematurely on this account should not nurse their babies, as their milk is usually poor, and they are not in good condition. In cases where the mother has had a little albumin in the urine, and a somewhat increased blood-pressure during the latter months of pregnancy, nursing does not necessarily need to be prohibited, but the baby needs to be watched carefully, as it is very likely that the breast milk will not be abundant in amount or of particularly good quality.

The Abnormal Breast-fed Baby.—*Vomiting in the Early Days.*—Not a few newborn babies vomit or regurgitate considerably during the first week, and often are unnecessarily weaned on this account. This is a great mistake, as this type of vomiting almost always ceases as soon as the mother is out of bed and lactation has been well established. Many times I have seen babies who were vomiting nearly every feeding in the hospital stop as soon as the baby and mother went home, and the mother began to be up and around. Particularly if the colostrum corpuscles persist in the milk for a longer period than is usual, the baby is likely to vomit. Colostrum is normally yellow in color, and in some cases this yellow color is greatly intensified, and may persist for a week or ten days. In several cases with this deep yellow breast milk that I have seen the baby has vomited excessively. The yellow color is not always due to colostrum corpuscles, as in one case the milk was a deep lemon color, and no colostrum corpuscles could be seen under the microscope. In this type of milk the fat is usually, but not always, high. The pigment is probably a combination of carotin and xanthophyll (see Chap. III), and is contained in the fat globules. These pigments come from the chlorophyl in green vegetables and fruits, and in any case with yellow breast milk where the baby is upset these should be omitted temporarily from the diet.

The most common cause of vomiting in the early days is improper technic in taking care of the baby. This occurs especially in hospitals, where one baby may have five or six different nurses take care of him during the course of the day, each with different methods of handling. He may be kept quiet after nursing or he may not be—one nurse may handle him with quick, jerky motions, another slowly and deliberately—his diapers may be changed when they are wet or dirty, or they may stay on him for hours. All these things upset a baby, and there is no question that in many of these vomiting babies the trouble is caused by "too many cooks." Newborn babies, as a rule, do far better at home than they do even in the best lying-in hospital, although in the days when so many people live in small apartment houses the lying-in hospital is a necessity. There should be special nurses for the nursery, however, whose sole duties should be to look after the babies.

Another cause of vomiting in the early days of life is an overabundant supply of breast milk. A baby a week old naturally has a good deal smaller stomach than an older baby, and if the breast is a fast one and there is a large amount of milk in it, he may get so much at each feeding that he vomits the overflow and sometimes the rest besides. The treatment of this type of vomiting is simple and satisfactory, and consists in increasing the interval between nursings, reducing the time of each individual one, and in stopping for a minute or two several times during the nursing.

Occasionally a baby will be seen who vomits more persistently without apparent reason, and all attempts at treatment are unavailing. No baby should be weaned during the first two weeks on account of vomiting, no matter how bad it is. If the vomiting is persistent and resists all measures of treatment, pyloric stenosis should be considered, and appropriate treatment instituted. In a few cases, although pyloric stenosis is evidently not present, and all methods of treatment are tried, the vomiting persists, and the baby does not gain weight. These babies must be weaned.

Underfeeding.—The underfed breast-fed baby is common. Underfeeding is manifested especially by failure to gain properly —1, 2, or 3 ounces a week instead of the usual 6 or 8. There are usually, but not always, symptoms of hunger, sleeplessness, irritability, etc. The stools may be small and constipated, or typical "starvation" stools may be passed, which are rather small in size, brown in color, contain considerable mucus, a few curds, and seem sticky in consistency. Such stools as this mean usually not indigestion, but underfeeding. The underfeeding may be qualitative or quantitative, that is, the breast milk may contain an insufficient amount of one of the individual food elements, particularly the fat, or it may be deficient in both quantity and quality. The most common deficiency is a lack of fat, and the fat percentage may be as low as 0.50 per cent. Combined with the low fat percentage is usually a high protein percentage, which may or may not give rise to symptoms of indigestion.

For practical purposes cases of underfeeding may be divided into two groups:

1. Those which are simply not getting enough to eat, but have no symptoms of indigestion.

2. Those which do not get enough to eat, and have indigestion also, usually from a too high protein percentage in combination with a low fat. The treatment of the first group is most satisfactory, and consists simply in giving the baby extra food in the shape of cow's milk modification. If there is not much deficiency in the breast milk the artificial feeding can be given immediately after each breast feeding in amounts suitable to the exigencies of the case and the age of the child. The amount to give can be determined approximately by weighing the baby before and after each breast feeding, and by finding out in this way how much he gets from the breast.

A series of such observations conducted over a period of several days give considerable information, and enables one to regulate accurately the amount of extra bottle milk which should be given. The following tables show the amount of

breast milk that an underfed baby of six weeks was getting, and also how the amount diminished in the course of two weeks:

January 19th:	3.30 A. M.	2 oz.
	7.00 "	4 "
	10.00 "	2 "
	1.00 P. M.	3.5 "
	4.00 "	1 "
	7.00 "	5 "
	10.00 "	1 "
	Total	18.5 oz.

January 20th:	7.00 A. M.	3.5 oz.
	10.00 "	2.5 "
	1.00 P. M.	3 "
	4.00 "	1 "
	7.00 "	1.5 "
	10.00 "	3 "
	Total	14.5 oz.

January 21st:	4.00 A. M.	2 oz.
	7.00 "	2 "
	1.00 P. M.	3 "
	4.00 "	3.5 "
	7.00 "	3 "
	10.00 "	3 "
	Total	16.5 oz.

The next three-day period, taken about two weeks later, shows how the supply of breast milk had diminished:

February 6th:	7.00 A. M.	3 oz.
	10.00 "	1 "
	1.00 P. M.	2 "
	4.00 "	1 "
	7.00 "	3 "
	10.00 "	1 "
	Total	11 oz.

February 7th:	7.00 A. M.	3 oz.
	10.00 "	2 "
	1.00 P. M.	2 "
	4.00 "	1 "
	7.00 "	2 "
	10.00 "	1 "
	Total	11 oz.

February 8th:	4.00 A. M.	1 oz.
	7.00 "	3 "
	10.00 "	1 "
	1.00 P. M.	2 "
	4.00 "	2 "
	7.00 "	2 "
	10.00 "	2 "
	Total	13 oz.

The giving of bottle milk immediately before or after the breast feeding is known as complemental feeding, and is usually

the best way to give extra artificial feeding, as the breast is stimulated with each nursing act in this way, whereas if several bottle feedings were substituted for several breast feedings, the breast would get no stimulus at these times, and the already deficient store of milk might be further reduced. There is no contraindication to giving cow's milk and breast milk together; indeed, it seems as though cow's milk were easier to digest when in the stomach at the same time with breast milk, and it is rare to have any symptoms of indigestion during mixed feeding of this sort. If the mother's supply of milk is very scanty indeed, and she has only enough to feed the baby perhaps twice during the day, it is best to let her do this, and to substitute a bottle for the other breast feedings. This is known as supplemental feeding. Unless the mother can give the baby two full breast feedings a day it is best to discontinue nursing altogether.

A baby should never be weaned simply because he does not get quite enough to eat on the breast; every few ounces of breast milk that he can get will help him, and the deficiency can be very easily made up with the bottle. Mothers and doctors, as a rule, do not appreciate this, and have a most unfortunate tendency to discontinue nursing entirely if the baby does not gain weight satisfactorily or if he seems hungry.

If the mother is leading a reasonable life, is well physically, has no worries, and is eating and drinking plenty it is not possible to do much toward improving either the quantity or quality of her milk. If she is overtired or overnervous the removal of the causes that have produced these conditions may bring about a betterment of her milk; if she does not eat the right sort of food or drink enough, a better balanced diet will help her.

The treatment of the babies who are underfed and who have symptoms of indigestion is more difficult. Here the baby does not gain weight, is fussy and irritable, is likely to vomit considerably, to have a good deal of gas and colic, with loose, green, curded stools. The difficulty here is also likely to be

caused by a too low fat and a too high protein percentage. The fat may be down to 0.50 per cent. and the protein up to 3 or 3.50 per cent. This type of milk is most likely to be seen in overworked, underfed women of the lower classes, or in highly strung nervous women of the upper classes. A good deal may be done for the milk of the underfed, overworked woman by mental and physical rest and a suitable diet, especially high in fats. Complemental feeding should, of course, be used at the same time. The highly strung, nervous woman, who has a poor milk more on account of the composition of her nervous system than on account of any errors in diet or hygiene, is a more difficult problem, and it may be necessary to wean the baby in such cases.

Overfeeding.—If a baby has indigestion with artificial feeding it is comparatively easy to tell from the symptoms and the character of the stools which food element is causing the trouble. This is not so easy with a baby fed on the breast. The stools of any breast baby with indigestion are likely to look very much the same, whether the trouble is due to fat, sugar, or protein. Occasionally, when the breast milk contains a very large amount of fat the stools may appear oily. Microscopic examination of the stools is by no means always reliable if the baby is breast fed, for there is so much fat in any good breast milk that there is likely to be a large amount of it in the stools of any normal breast-fed baby. The general symptoms of overfeeding or of indigestion due to any one of the food elements are vomiting, colic, gas, frequent green curded stools, poor sleeping, and failure to gain properly.

Much trouble is caused by too frequent and irregular feedings. The baby's stomach does not get a chance to empty itself before new food is introduced; part of this will probably be vomited, the rest enters the small intestine, where, on account of its large amount, it cannot be wholly absorbed. What is not absorbed undergoes fermentation, with the production of loose green stools, gas, and colic.

The first thing to do is to increase the interval between the

feedings if it is too short, and to see also that the baby is fed with absolute regularity. Also a couple of tablespoonfuls of lime-water, or of plain boiled water, can be given before each nursing, in order to dilute the milk, and the time of nursing can be shortened from fifteen or twenty minutes to eight or twelve minutes. Most babies who are getting simply too much milk of normal composition at too frequent intervals will respond readily to this treatment.

If these changes do no good, the composition of the breast milk should be determined by analysis. The sugar varies the least of any of the food elements; the fat and the protein may vary considerably. The German school believes that all breast milk is good milk, that excessive amounts of the individual elements do no harm, and that disturbances of digestion or of nutrition are always due to underfeeding, overfeeding *in toto*, sickness of any sort in the baby, or faulty methods of caring for him. While it is undoubtedly true that many breast-fed babies thrive on milks of markedly abnormal composition, it is also true, in our opinion, that abnormality in the composition of the breast milk accounts for indigestion in a great many cases. Breast milk analyses are entirely unreliable unless the milk is obtained in a certain way, and unless the analysis is done by exact quantitative methods by a competent chemist. Either the whole contents of the breast should be sent for analysis or the middle portion of the nursing. In practice it is usually simpler to obtain the middle portion of the nursing. The baby is permitted to nurse about a quarter of his usual time, then an ounce or two of breast milk for analysis is expressed either manually or with a pump. The fore-milk or first portion of the nursing is very low in fat, the strippings, or last portion, is rich in fat. The middle milk gives a fairly accurate representation of the average composition. If the percentage of fat is found to be too high, the best way to reduce it is to have the mother eat less food in general, and exercise more. If the percentage of protein is too high, exercise and freedom from nervousness and household cares may diminish it. Dimin-

ishing the protein in the food probably has little effect in diminishing the protein in the milk. Although the sugar may not be excessive in amount, it may none the less be the cause of indigestion. There is no satisfactory way of influencing the amount of sugar.

In general it is rather difficult to treat a breast-fed infant with indigestion. With bottle feeding we can change the amounts of the various food elements in the diet at will, and we can usually tell very easily by the stools which element is causing the trouble. With breast feeding, on the other hand, we are working at a considerable disadvantage. The picture is not nearly so clear, and it is much more difficult to change the character of the milk. Furthermore, indigestion may occur even when the breast milk is apparently perfectly normal in composition. In this group of cases particularly, but also in any case with an excessive number of stools, and evidences of intestinal fermentation, an ounce or two of fat-free lactic acid milk or buttermilk given immediately after the shortened nursing period may help a great deal, and is one of the most satisfactory methods of treatment. A half teaspoonful of powdered casein (Larosan, Casec) dissolved in a tablespoonful of water, and given after each feeding, is also efficient in cases which are due to sugar or fat fermentation.

It is our duty to go through all methods of treatment before weaning the baby, and in most cases weaning is not necessary. Occasionally, however, the baby fails to do well, no matter what we do, and breast feeding has to be discontinued.

CHAPTER V

THE DEVELOPMENT OF MODERN ARTIFICIAL FEEDING[1]

The artificial feeding of infants has been, is, and probably will continue to be a much discussed subject. Our opinions regarding it are constantly changing and developing; its literature is assuming enormous proportions, and each year we are learning more and more concerning the fundamental nutritional processes of the infant, upon which all nutritional therapy depends. It is in a constant state of flux; certain ideas are in the foreground for a few years and then gradually recede, leaving, however, their faint or pronounced marks upon the fabric of the whole. The healthy infant has the power, in a large measure, of adapting itself to widely varying artificial diets; this accounts to a great extent for the success that pediatricians in different parts of the world have had, using their own particular methods, which may differ considerably. There is no one way to feed an infant; it is true that he must be fed a food that furnishes enough fuel value; also that he must have a food which he can digest and which contains the proper materials for the growth of his body; but it is possible to meet these demands in a variety of ways. We know, even at the present time, comparatively little about the factors which are concerned in the disturbances of digestion and of nutrition; furthermore, babies fed according to one method are likely to have somewhat different types of disturbance than those fed according to another method; therefore there is plenty of chance for different ways of looking at these disturbances, and for difference in their classification.

[1] This chapter appeared in the Boston Medical and Surgical Journal, vol. clxxii, No. 13, 1920 and I am indebted to the editors for permission to reprint it.

Liberality, broadness of vision, and respect for the opinions of others are essential in medicine; in no branch of medicine are these qualities more essential than in infant feeding. There are many ways of approaching the subject, many viewpoints of value besides the ones which we may ourselves happen to hold, and it is vital in order to have a clear vision of the subject to give heed to the thoughts of every competent observer, to adopt what seems good in his teachings, and to amalgamate it with our own ideas.

Therefore, it should be of value to consider the development of modern infant feeding, the opinions that have been held by the great teachers of the subject, their influence upon those who have followed them, and their relationship to the teachings of the present day.

Biedert, Meigs, and Rotch (the Protein Period).—Modern infant feeding may be said to have started with Philip Biedert's inaugural dissertation in 1869. Previous to this time but little scientific investigation had been produced in connection with it; the little that was known was almost entirely empirical and the results of artificial feeding were uniformly bad. Biedert's monograph of 64 pages is entitled "Investigations Concerning the Differences Between Human Milk and Cow's Milk." Previous to his time there were on record many analyses of cow's milk, but few of human, and the figures varied so widely that it was quite certain that but few of them could be correct.

Cow's milk was supposed to contain about 5 per cent. of casein, human milk, 4 per cent. Biedert started with the central idea that in order to have a rational basis for the artificial feeding of infants it was necessary to know the exact composition of human milk, the baby's natural food, and then to imitate this as closely as possible in the artificial mixture. He showed by many analyses that the amount of casein in human milk was very much less than that in cow's milk, about 2 per cent., he believed. He also laid especial stress on the fact that cow's milk when treated with acid formed large tough curds, and that human milk formed very small soft curds. This was due, he said, not only to the fact that there was much less casein in

human milk than in cow's, but also that the casein was different qualitatively; cow casein was an entirely different substance from human casein. He called all the protein of milk casein, and did not know that lactalbumin was also present; with him "casein" and "protein" are synonymous terms. His two basic conceptions: that the protein of human milk is less than half that of cow's milk and that the proteins are of different quality were fundamentally correct, and were of epoch making importance. We shall find that for many years thought in infant feeding was greatly influenced by them. He believed that the ratio of fat to casein in human milk was as 3.5 to 2—that in cow's milk it was as 4 to 5. The more fat there was in relation to the amount of casein present, the more likely was there to be a soft curd; this was the reason that the curd of human milk was soft and small, and the curd of cow's milk was hard and large. Also, he thought that a certain amount of protein was necessary to hold the fat in emulsion and facilitate digestion; thus we see the beginnings of the idea of the importance of the ratio between the food elements.

Biedert wrote many articles after his first one, and in 1880 the first edition of his text-book appeared, going through four editions, the last in 1900. His central idea was the indigestibility of the cow casein, and his methods of feeding were all based on this. He believed that a mixture should be made in which the amount of casein should be reduced considerably below that in human milk (to 1 or 1.50 per cent.) and that the ordinary milk and water dilutions then in use did not accomplish this. In order to raise the nutritional value of the food and also to aid in the digestion of the curd, he used dilutions of cream or mixtures of whey and cream. In his cream dilutions there was a ratio of fat to casein as of 2.5 to 1, which he thought was the most favorable one for the proper digestion of the casein. The cream mixture usually had sugar added up to about 5 per cent.

Besides his regular cream dilutions he developed his famous "cream conserve," a thick paste which would keep for a con-

siderable period, and which needed simple dilution with water before using. This was made from casein, butter, milk, and cane-sugar, and the salts of milk. When diluted, according to his directions, it contained about 2.50 per cent. fat, 4 per cent. sugar, 1 per cent. protein, and 0.20 per cent. salts. He recommended this for use only when fresh milk could not be obtained, and was always a vigorous advocate of mixtures made from fresh, clean milk. He attacked especially the various condensed milk mixtures and proprietary foods which had begun to spring up, and insisted that nothing could ever take the place of fresh cow's milk. Most of his writings are concerned with the chemical differences between human milk and cow's milk and the proper mixtures to feed to normal babies.

In the first edition of his text-book there are 377 pages, 321 of which are devoted to these subjects, and only 56 to pathologic conditions, nor did he attempt any special classification of digestive disturbances. He believed that most digestive troubles were due to the casein curd, he denied the good of the gruel and milk dilutions in general use, and advised strongly against feeding starch to small babies. The sugar, he thought, was practically harmless and did not recognize any particular type of indigestion caused by it. He found, however, that if too much fat was fed diarrhea resulted in certain babies, and that in these cases the fat might be as much as 50 per cent. of the dried stool. He looked at these stools microscopically and mentions the presence of an excess of fat droplets. The condition was, he said, probably due to a duodenal catarrh, which hindered fat absorption. He also described very dry white stools containing an excessive amount of fat, and thought they were due to a lack of bile secretions ("soap stools"). He believed that failure of fat absorption might have considerable importance in causing infantile atrophy, but that in acute disturbances the casein was more important.

Biedert was a scholar, a shrewd observer, a clear writer, and his ideas influenced the trend of thought in infant feeding for twenty years or more.

Developments in America. Influence of Biedert.—In 1880 Dr. John Forsyth Meigs of Philadelphia was the most successful and most widely known feeder of infants in America. His methods were largely empirical, but he got better results than had ever before been obtained. About this time he asked his son, Dr. Arthur V. Meigs, to make for him some analysis of condensed milk. This led the younger Meigs to investigate the composition of breast milk, to which he devoted a great deal of time, being interested in it up to the time of his death in 1911.

Meigs states his fundamental ideas as follows: "There are but two possible methods in endeavoring to reach a conclusion about what is right to feed babies, the one purely empiric; to experiment with various foods until the best is found; and the other by analysis to learn as nearly as possible what human milk is, which we all know to be the most perfect food for infants, and then to make an imitation of it."

In 1882 he made the statement, following much experimental work, that human milk never contained more than 1 per cent. of casein, and this statement may be said to be at the bottom of most of his ideas on feeding. This was about half Biedert's figure for the amount of casein present in human milk. Inasmuch as this is the figure for human milk, said Meigs, in artificial feeding more than 1 per cent. of casein should never be in the cow's milk mixture offered to the baby. In making a food for babies two matters should be considered: the constituents must be in the same relative proportions as they are in human milk, and they must be in a medium which shall be as human milk is, alkaline. Furthermore, it is a great mistake to keep changing a baby's food in the early months; the baby should be started on a food which shall imitate breast milk and this should be fed to him without change in strength until he is eight or nine months old. He can take as much of it in amount as he desires, however. Meigs gives the following directions for preparing this food: "One quart of whole milk is put into a pot or a high pitcher and allowed to stand three hours; then

one pint is poured from this. When the child is to be fed there are taken of this weak cream 3 tablespoonfuls; of lime-water, 2 tablespoonfuls; of sugar-water, 3 tablespoonfuls. This makes 4 ounces of food. Sugar-water is made by dissolving 18 drams of lactose in 1 pint of water. This mixture contains about 4 per cent. fat, 7 per cent. sugar, and 1 per cent. protein—according to Meigs an exact imitation of mother's milk. He fed this to babies of all sizes and ages, in all stages of malnutrition. His results in hospital practice were rather disappointing, he says, and a good many of his babies died, but in private practice the results were most gratifying.

In 1885 appeared his little book, "Milk Analysis and Infant Feeding," most of which he devoted to a technical discussion of his methods of milk analysis, and very little to practical feeding.

Meigs summarizes his principles as follows: "The end to be striven for in order that a more general success may be attained in the artificial feeding of infants is to diffuse more widely and to make common property of the knowledge of the small amount of casein in human as compared with cow's milk, and that, in addition to the dilution which is necessary to reduce the amount of this constituent, we must use in proper proportions cream, sugar, and lime-water."

Meigs' influence was felt all over the country and his ideas were widely followed. He had worked along the same lines as his predecessor, Biedert, but had added to his work in that he came nearer to the actual amount of casein in human milk, and devised a more exact formula to be used in the imitation of the baby's natural food.

Rotch.—About 1887 Dr. Thomas Rotch of Boston began to be interested in infant feeding. He was well acquainted with the literature of the day, and was influenced very largely by the teachings of Biedert. About the time that Meigs was doing his work in Philadelphia, Rotch began to study various infant foods. On his service at the Infants' Hospital the best results were being obtained with condensed milk. This led him to make an analysis

of the condensed milk mixtures that were being fed, and he found that most of them contained very close to 1 per cent. of casein. From this he argued that 1 per cent. of casein was probably the best amount to use, so he turned to Meigs' mixture, and gave it a thorough trial. He soon began to see, however, that it had its limitations.

He said, "We began to appreciate that the infants' idiosyncrasy was not for any one of the especial combinations usually found in human milk, such as high or low total solids, or in other words, a strong or a weak mixture, but that any one of the various constituents, according as it was in high or low percentage, might be the cause of what was represented by the especial idiosyncrasy, and thus we arrived at the conclusion that in a multitude of variations and degrees the human infant may have an especial idiosyncrasy for a high or low percentage of any one of the food-stuffs or for any combination of them. Resulting from this we deduced that to obtain a successful feeding and nutrition for infants we must be able to prepare an almost innumerable number of foods, varying in the percentage of any one of their ingredients, and in the combinations of these percentages. Percentage feeding is the variation of the individual food elements so that we can give various babies the percentages of these elements which are adapted to their special digestions."

These were revolutionary ideas and epoch making. Rotch cast down at a blow the teachings of the day, that human milk must be imitated, and the same mixture fed to all babies. To him we owe the birth of the idea of individualization and variation. He looked upon digestive and nutritional disturbances as being caused by elements in the diet rather than by the diet as a whole, and emphasized strongly the necessity of thinking of the food in terms of its elements.

He followed Biedert in the belief that the casein was the cause of more digestive troubles than any other food element, and recommended feeding it in very small amounts to young babies especially—smaller even than Biedert had used. The

fat he regarded as secondary to the casein in importance; the sugar he thought least important of all. He devised the gravity cream and skimmed milk method of modification, which allows of great elasticity in the preparation of milk formulæ, and almost any ratio between the various food elements that is desired. He started milk laboratories in 1891 where the food was prepared exactly according to the doctor's prescription and delivered to the home ready for use. He insisted upon the necessity of thinking in percentages, and the physician's knowing as accurately as possible what is in the mixture that is being fed to a baby. He believed that very small variations in the percentage of the elements in the food were of very great significance. He wrote many papers of importance, and for long was regarded as the greatest American authority on infant feeding.

Retrospect of Biedert, Meigs, and Rotch.—To Biedert we owe the first really important scientific investigations in infant feeding, and the proving that human milk and cow's milk are very dissimilar in composition, especially as regards their casein content. To Meigs we owe a more accurate analysis of human milk, and the wide-spread diffusion of his own and of Biedert's ideas in America. To Rotch we owe the great principle of individualization, the new conception that it is not the food as a whole, but its elements that must be considered. Much of the teachings of these men, in the light of our present knowledge, does not seem to be, and is probably not, correct, but they may be regarded, however, as three of the great pioneers in infant feeding. Biedert, Meigs, and Rotch devoted most of their time to the study of what to feed to the baby; their classifications of digestive disturbances were quite secondary and relatively unimportant. They did very little regarding the physiologic, bacterial, and chemical processes within the baby's body; they studied his food rather than himself. The next four men that we have to discuss—Widerhofer, Escherich, Czerny, and Finkelstein—studied the baby primarily and his food secondarily.

Widerhofer, of Vienna, was essentially a pathologist. Viennese medical thought in his day was largely influenced by the studies of Rokitansky, the greatest student of gross pathology. It was the age of anatomic pathology: Rokitansky in Vienna and Virchow in Berlin were the two greatest pathologists in the world, and their influence was felt everywhere. In every branch of medicine changes in anatomic structure, both gross and microscopic, were made the basis of classification. It was natural for students of infant feeding to apply these principles to their work. They attempted to find for every clinical picture anatomic changes in the organism, and Widerhofer's classification is almost entirely an anatomic one. In Gerhardt's Handbook of Diseases of Children, published in 1880, he writes a very complete chapter on gastro-intestinal disease in babies, from the standpoint of a pathologist. He recognizes innumerable pathologic conditions, each of which he believes has a corresponding clinical picture.

Some of his main divisions are as follows:

1. Acute gastritis.
2. Chronic gastritis.
3. Dilatation of the stomach.
4. Toxic gastritis.
5. Melena.
6. Dyspepsia.
7. Enteralgia.
8. Acute and chronic enterocatarrh.
9. Follicular enteritis.
10. Membranous enteritis.
11. Croupous and diphtheric processes.
12. Syphilitic enteritis.
13. Amyloid degeneration.
14. Cholera infantum.

Such a classification as this is very unsatisfactory, as it does not sufficiently take into account the processes which have produced the pathologic picture. Furthermore, in many of the severest types of gastro-intestinal disturbance in babies

there are no pathologic lesions that can be demonstrated, either in gross or by the microscope. The changes are largely of function rather than of structure. Widerhofer's classification lasted some time, however, and traces of it are still to be seen in several modern text-books. Most authorities are agreed, however, that the viewpoint of anatomic pathology is not the best one to adopt in considering these disturbances.

Escherich.—No consideration of the development of infant feeding would be complete without reviewing the work of Theodore Escherich, although he proposed no new system of feeding or of classification. In his day (1886) the science of bacteriology was in its infancy, and he was the first to study carefully the bacteria in the infant's intestine, and to show the significance that they had in the normal and abnormal intestinal processes and their relation to food in the intestines. He investigated the normal intestinal flora, and showed that it was of two sorts, the fermentative and putrefactive. He showed how the bacteria are necessary for the normal functions of digestion, and how they may cause trouble. He was the first to see clearly that there are two processes going on in the intestine: putrefaction of protein and fermentation of carbohydrate, and he laid down the great principle that the types of bacteria that exist in the intestine are dependent upon the kinds of food fed. That high carbohydrate feeding favors the growth of one group of bacteria, that high protein feeding favors the growth of another group, and that if one type predominates and if the excessive breaking down of either carbohydrate or protein results, the baby gets into trouble. He recognized the fact that when carbohydrate fermentation exists carbohydrate should be withdrawn from the diet, and protein substituted, to change the type of intestinal flora, and vice versa. This is a fundamental principle which cannot be neglected in infant feeding. Indeed, I do not believe it is exaggerating to say that in dealing with abnormal intestinal processes it is the most important principle of all, and nobody can feed babies successfully without taking it into consideration. Bacterial proc-

esses in the intestine, and their relationship to the food supply can never be separated from questions of practical infant feeding, either normal or abnormal. In Escherich's own words, "The fact that through designed changes in the food supply the character of the bacterial vegetation, and all the processes that go with it, can be altered, opens to us a broad and remunerative perspective, and in order to apply our knowledge of intestinal bacteriology practically the first and most important thing is a thorough study of bacterial processes in the *normal* intestine. May the views put forth here not be without practical value in the treatment of that murderous pestilence of the first year of life—diarrhea."

Czerny and Keller (the Fat Period; About 1900).—Previous to Czerny, as we have seen, much had been accomplished in the study of the baby's food, of intestinal bacteria, and of the pathology of the intestine; attention had been focused either on the food before it was given to the baby, or on the digestive processes in the bowel; not enough had been given to a consideration of the baby as a whole, and the effect of the different food elements in normal and abnormal conditions upon the general metabolism. It remained for Czerny to take a broader view, to suggest the term "disturbances of nutrition" instead of "gastro-intestinal diseases," and to follow carefully the etiologic influence of the various food elements in causing these disturbances. "A study of the general metabolism allows us to follow the fate of the food-stuffs after they have passed through the digestive tract and the influence of unsuitable nourishment upon the whole organism of the infant. Metabolic studies do away with empirical methods of feeding."

Czerny and Keller's monumental text-book on infant nutrition appeared in several parts, the first part coming out in 1906. It is really a marvelous book, showing a broad knowledge and a great power of putting together facts and theories to make a harmonious whole.

Czerny and Keller's classification of nutritional disturbances is an etiologic one, and was undoubtedly the best that had

appeared up to that time. They divided nutritional disturbances into three broad groups: (1) from food, (2) from infection, (3) from constitution.

In the first group comes: (1) fat injury, (2) starch injury, (3) gelatin injury, (4) scurvy.

They describe with great clearness the picture of *fat injury* (Fettnährschaden) and consider it one of the most important of all food injuries. It arises from overfeeding with fat, is evidenced by constipation, pallor, loss of turgor, and failure to gain. They consider fat the most important of all the food elements in causing nutritional disturbance.

Starch injury (Mehlnährschaden) comes from a one-sided starch diet in the first few weeks of life especially. The baby is much emaciated from lack of nourishment. He has had just enough starch barely to keep him alive, but no more, and his body cells are dying from lack of salts and protein. Thus we see the results of the food injury extending beyond the intestine and affecting every cell in the body; a true metabolic disease is present, and not a mere "indigestion."

Czerny also attacked the old supposition that protein was the most important cause of digestive troubles. He believed it did practically no harm, and did not recognize any such thing as protein injury in his group of food injuries. This was revolutionary, as previous to him attention had been focused on the protein, and all the attempts in milk modification had one particular end in view, to make it of easy digestion. He says, "There is no single symptom which can show us injury to the infant through protein, and from the standpoint of the clinician it is impossible to speak of a protein injury. It is possible that with abnormal flora in the intestine, putrefaction of the casein *might* occur. It is, however, as yet unknown whether or not this actually does happen; and, furthermore, if it should occur, whether or not it has anything to do with nutritional disturbances. In overfeeding with milk, in our experiences, a fat injury, and not a protein injury, occurs. Overfeeding with protein is hardly possible; it is much more likely that in an artificially

fed baby there should be protein underfeeding. We cannot take into consideration a disturbance of nutrition from protein."

Disturbances of nutrition from infection include all conditions which might be caused by bacteria or their products: (1) Infection of the food before it enters the body in such a way that toxic products are formed in it. (2) Infection of the food in the intestine. (3) Infection of the intestinal mucosa itself. Alimentary intoxication is a condition in which the symptoms are caused by the toxic products of destroyed food; in enteral and parenteral infections the trouble is caused by the bacteria themselves attacking the body; in the former group by infecting the intestinal wall; in the latter group by infecting other parts of the body and causing gastro-intestinal and nutritional disturbances secondarily. There are two types of alimentary intoxication: one in which chiefly sugar is being decomposed; one in which the fat is. Fever in these conditions means an injured intestinal wall which makes it permeable for bacteria or their toxins, and very small injuries to the intestinal wall may allow this. The acids from fat or from carbohydrate decomposition are the starters of the trouble in alimentary intoxication. These may be introduced in spoiled milk or may arise in the gastro-enteric tract from bacterial decomposition of food. The symptoms of intoxication have many causes, of which only a part are as yet known. It can be assumed as true that a part of the symptoms are caused through water and salt loss, another through the absorption into the body of toxic material from the intestine which could not normally pass the intestinal wall, and finally, acidosis must be taken into consideration. Special toxins have as yet not been discovered. Special toxins are not necessary, however, to explain the clinical picture, as nearly all the symptoms are dependent upon disturbances of the intermediary metabolism which are brought about by the pathologic processes in the digestive tract.

As to milk modification, Czerny recommends simple milk dilutions with addition of carbohydrate—one-third milk, two-thirds water for a baby in the first few weeks; then one-half

milk, one-half water; later, two-thirds milk, one-third water, and finally, about the eleventh month, whole milk. He does not believe in the use of cream in any way, as it is likely to cause fat injury.

We owe to Czerny the first really adequate study of the nutritional disturbances, and the most comprehensive classification of them that had yet appeared.

Finkelstein.—The teachings of Finkelstein and his co-workers, Langstein and Meyer, began to come into prominence about 1907, and from then up to the present time have received a great deal of attention. Finkelstein's chief contributions may be summed up in four phrases: sugar, salts, clinical classification, and protein milk. Sugar had been, before his day, comparatively neglected as a source of digestive and nutritional disturbances; he makes it the cause of most of them. He studied carefully sugar fermentation in its different degrees, and the results of sugar fermentation, both immediate and remote. Sugar fermentation can be brought about in many different ways, but it is most likely to ferment in a medium which is rich in whey salts, particularly sodium salts. It is the whey salts of cow's milk which are injurious, and not the protein. The whey salts depress the antibacterial function of the cells of the small intestine and thus allow too profuse bacterial growth and consequent fermentation of the sugar. The intestinal mucosa is impaired functionally by the acids which are formed from sugar fermentation, and this functional injury allows the salts and unaltered lactose to pass through it into the general circulation. Finkelstein at first thought that the lactose was the cause of the fever and symptoms of intoxication which occur in some of the more severe cases of sugar fermentation, but later changed this view, and came to regard the salts as the cause of fever. Bacteria and bacterial toxins he does not consider important, except as they are concerned in the original fermentation. His new and startling ideas concerning the salts have caused a good deal of discussion, and have stimulated much research, some of which is in accord with his views, some

of which is not. Protein never does any harm, and fat is harmful only when there is a primary sugar injury; sugar is the one particular thing that causes trouble for babies. Thus we see that every food element in its turn has been considered the chief offender—with Biedert, Rotch, and Meigs the protein, with Czerny the fat, and lastly, with Finkelstein, the sugar and the salts.

Finkelstein's classification of nutritional disturbances is likewise different from anything that preceded it. He sees these conditions with entirely new eyes, and builds up a most ingenious edifice in his classification and treatment. His classification is purely clinical; he recognized and studied carefully certain conditions that babies get into through errors in digestion or nutrition; the etiology of those conditions is a secondary consideration. He says, "An etiologic diagnosis I hold to be practically impossible, and if it were possible—not desirable. How little, for example, does the diagnosis 'nutritional disturbance from infection' mean, when it remains in the dark where the origin of the condition lies, whether from secondary dyspeptic fermentation or other causes. It is best to discard all etiologic nomenclature and to adopt the clinical; it is desirable for the physician to be able to say what sort of child he has before him and how this child will react to definite dietetic influences." He admits himself that his classification is by no means perfect, and doubts whether there ever can be an absolutely satisfactory classification, as many of the various disturbances shade into one another so closely that it is impossible to separate them thoroughly. To each food of a certain composition there belongs a certain type of disturbance, and there must be as many types of disturbances as there are combinations of food elements.

His four main clinical groups are as follows: (1) Disturbed balance; (2) dyspepsia; (3) intoxication; (4) decomposition. By disturbed balance he means especially the fat injury of Czerny. A baby has previously done well despite adequate or overadequate caloric intake, does not gain, or may actually

lose. Instead of a gain of weight resulting from an increase of food, a loss is likely to result (the "paradoxic" reaction). The food which brings about this disturbance is usually a food rich in fat and protein and relatively poor in carbohydrate; according to Czerny, overfeeding with milk; according to Finkelstein, underfeeding with carbohydrate. His principles of treatment are essentially the same as those of Czerny; reducing the amount of milk and adding carbohydrate in the form of maltose and starch.

2. Dyspepsia is the milder form of sugar fermentation. In this condition the process is localized in the intestinal tract, the loss of weight is not large and there are no symptoms of intoxication; the baby, as a whole, does not suffer, nor are there serious symptoms unless the condition is untreated or treated wrongly. Dyspepsia is likely to arise from food rich in sugar and whey salts; is favorably influenced by a food low in sugar and high in protein.

3. Intoxication represents a severe metabolic disturbance. It may have started as a dyspepsia, or may be engrafted on to a decomposition. The process here is not localized in the intestine, the whole organism suffers; the child's body is in a state of "metabolic bankruptcy," there is chaos where there should be order. The temperature is high and the baby's general condition bad. The baby is losing nitrogen, water, and salts, and there is likely to be considerable acidosis present. The fever and most of the untoward symptoms are caused by the whey salts, which have gone through the unhealthy intestinal mucosa into the general circulation. The prognosis is grave. This is the condition which Czerny also describes under the head of alimentary intoxication, although he does not believe it is due to as specific causes as does Finkelstein. He believes it is a resultant of several conditions, many of which we know little about.

4. Decomposition represents what was known to the older writers as "marasmus," "athrepsia," or "infantile atrophy." The condition may arise in a number of ways, either as a result

of a prolonged "balance disturbance" or a chronic dyspepsia, from an improperly treated intoxication or from prolonged underfeeding or improper feeding. The chief thing about decomposition is the very low tolerance for food; increasing it beyond the limit of tolerance may result either in dyspepsia or intoxication. The baby's body is actually decomposing, every cell in the body is affected, and the organism is not able to assimilate food, even if the digestive processes in the intestine were not impaired.

In order to treat sugar fermentation Finkelstein desired a milk preparation very low in sugar and high in protein. The purpose is to inhibit sugar fermentation by withdrawing the fermenting substance, and to change the bacterial flora of the intestine from carbohydrate splitters to protein splitters by offering a low carbohydrate and high protein food; to promote an alkaline instead of an acid intestinal contents. For this purpose he devised the famous "eiweiss" or protein milk, a preparation containing fat 2.5 per cent., sugar 1.5 per cent., protein 3.5 per cent. This was made from equal parts of buttermilk and water to which a certain amount of finely sifted milk curd has been added. The principle of protein milk feeding is undoubtedly one of the most important advances ever made in infant feeding, and pediatricians all over the world have become convinced of the worth of Finkelstein's milk or modifications of it. Used in the right type of case, it is without question remarkably efficacious, but like all good things it has been used too much, and in cases in which there is no possible indication or need for it. It is not a universal food for all feeding troubles, but is merely one more very excellent weapon added to our armamentarium.

As does Czerny, Finkelstein recommends simple dilutions of whole milk for feeding most babies, and following him, this method of feeding is used by most of those who have studied in Germany. It has the advantage of simplicity, but does not offer the wide variety of choice in the various combinations of the food elements that the older methods of cream dilutions

and cream and skimmed milk modifications do. In the last ten years the influence of Finkelstein has been profound, and it is probable that his teachings are followed more than those of any other authority at the present time.

What conclusions may be drawn from this brief résumé of these various stages in the development of infant feeding? Can we believe that we in the present epoch are entirely right, and that our predecessors have been wrong? This is hardly reasonable, and yet each epoch has been insistent that its ideas are the best, which is only natural. Any period in the development of any human activity is at best only an imperfect fragment, and as research advances many of the old ideas are discarded, some retained, and some modified. Any period in the development of any science always owes most of its ideas to the thought of those periods which have preceded it. This is particularly true of infant feeding. There has been in infant feeding no one startling discovery, such as has occurred in most other branches of medicine; its progress has been rather in the nature of a gradual development, and it is still in the developmental stage. When we realize that most of what we have come to believe as true regarding infant feeding has been developed in the last fifty years, it is not difficult to grasp what enormous changes may take place in the next fifty. We are at present in a period—the period of sugar—we have gone through the period of protein and of fat. As we learn more our present ideas will undoubtedly change and the infant feeding of 1950 will probably be little like that of 1920. Whatever classification we use, whosesoever teachings we adopt, we must realize that there is more than one way of looking at the subject. If we adopt Rotch's teachings, Finkelstein's need not necessarily be wrong; or, if we accept Finkelstein's, Czerny's need not be considered erroneous. Rotch's postulate of knowing approximately the percentage composition of the food we offer, and expressing our milk modifications in terms of percentages of the food elements, can perfectly well be combined with the teachings of Czerny and of Finkelstein, and should be.

Something has been gained, something has been added to the whole, by each of the various periods, and the teachings of all these different men are not incompatible. Czerny's classification is excellent, so is Finkelstein's; babies undoubtedly do suffer from fat, likewise from sugar. Some things are not sound in the teachings of either; these will soon be discarded and the good points will remain. Much of Rotch's teachings we do not agree with today—but his main principle, that we must have some method of feeding which will allow us variation in dealing with the individual, some method by which we can express accurately and concisely to others what combination of the food elements we are feeding to any given baby, will always remain. This principle is absolutely sound, and cannot be passed over. It is a pity that European students have not paid more attention to American methods, and it is rare indeed to see a reference to the name of any American author in a German text-book. We in America are far ahead of any method that Europe has yet produced in the modification of milk. European students are far ahead of us in the study of the normal and abnormal chemistry of the baby. As I said before, studies in this country have dealt chiefly with the baby's food and how to prepare it; German studies chiefly concern the baby himself. German methods of milk modification have little elasticity; their whole milk mixtures are, in many cases, quite inadequate. We can learn much from them, however, concerning abnormal processes in the baby, concerning the pathogenesis of the digestive and nutritional disorders, and we should combine our own ideas of milk modification with their ideas of the baby. There are too many practitioners in this country who feed blindly; they have not the remotest idea of the underlying reasons for their procedures, and we can arrive nowhere, no matter how carefully our milk modifications are prepared, or our percentages calculated, unless we understand the fundamentals of the science of nutrition, the digestion and absorption of the food-stuffs, their influence upon each other and the influence of the intestinal bacteria upon them all.

Different sections of the country use different methods and look at feeding problems somewhat differently, despite all that has been written, "that we all feed the same." We do not all feed the same, and probably never will. In the last few years many American pediatricians, particularly from the Middle West, have studied in German clinics, have brought home the German ideas and have taught them in the medical schools. Followers of these methods have been rather inclined to look down on the older methods of "percentage feeding," and those who have been brought up in the old methods have given in many cases little heed to the new. The younger disciples of the German school have not investigated carefully enough the teachings of the older American authorities, nor have many of these older American authorities paid much attention to the newer German ideas. The two should be combined: German chemistry, American milk modification. More good research work in problems of infant nutrition is being done in this country than ever before, however, and it will undoubtedly be productive of much good. We owe to German investigators most of what we know regarding the baby's normal and pathologic chemistry; we owe to American investigators most of our knowledge regarding modifying cow's milk to make a suitable food for him. Infant feeding need not necessarily be made abstruse and complicated, but it must not, on the other hand, be made too superficial. *The practitioner must know his food elements and be able to trace them in their progress through the digestive tract; he must also have several methods of milk modification at his command, so that he can combine these elements in any way he desires to meet special indications; the various milk preparations and methods of milk modification are the "tools of the trade," as Dr. Rachford of Cincinnati has said.* Whatever we believe about the various food elements, we must realize that most of the time it is not exclusively one food element that causes trouble; it is rather improper combinations of the elements. We may be able to feed a baby successfully on a high fat and low protein, but as soon as we employ a high protein and high fat we may

begin to get trouble with the fat digestion. Large amounts of one element may be handled well by the baby, large amounts of two or more elements usually get him into trouble.

I can conceive of only two reasonable methods of classification, the etiologic and the clinical. Whichever we follow we must realize that the other is not necessarily wrong; it is merely another way of looking at the same phenomena; a difference in nomenclature rather than in actuality. My personal feeling is that the etiologic nomenclature is the more satisfactory, despite certain disadvantages; there are many, however, who would not agree with this. This nomenclature is advantageous in that it makes us think especially of the various elements and what they can do to the baby; it is dangerous in that it has a tendency to focus itself upon one element to the exclusion of the others, and it unquestionably does not describe the various conditions in which the baby may be, as well as does the clinical nomenclature of Finkelstein. There is no question but that at the present time Finkelstein's teachings are influencing infant feeding more than those of any other man or group of men. Many of his ideas will last, but a good many will undoubtedly be discarded as further progress is made. There is no telling what the next generation will bring forth, but judging from past history, our ideas concerning infant feeding then will bear little resemblance to our ideas now; in such a young science there is possibility of infinite change in the next few years. The salts and their relationship to the other food elements, their influence upon digestion and upon cell metabolism seem to offer the most fertile field for research and progress.

Realizing that we have by no means as yet reached the solution of the problem, we must be broad minded, must keep away from fads, must not focus on one point to the undue exclusion of others, must accept the fact that there is more than one way of looking at this most interesting subject, be not too assertive and dogmatic in our statements, and remember that what is apparently true today may be proved false tomorrow.

CHAPTER VI[1]

COW'S MILK

Average Composition.—The following table, from Heineman, shows the average composition of cow's milk, as given by different authors:

	Van Slyke. Per cent.	Bobesch. Per cent.	Richmond. Per cent.	Oliver. Per cent.	Fleishmann. Per cent.
Water	87.1	87.3	87.1	87.6	87.75
Fat	3.9	3.6	3.9	3.25	3.40
Casein	2.5	3.0	3.0	3.40	2.80
Lactalbumin	0.70	0.60	0.40	0.45	0.70
Total protein	3.2	3.8	3.4	3.85	3.50
Lactose	5.1	4.50	4.75	4.55	4.60
Ash	0.70	0.70	0.75	0.75	0.75
Total solids	12.9	12.7	12.7	12.4	12.25

The most common figures used are:

Fat	3.5 to 4 per cent.
Lactose	4.50 per cent.
Protein	3.50 "
Salts	0.70 "

There may be considerable variation in the composition of milk from different cows; therefore, it is best in infant feeding to use the milk from a mixed herd, the fat standard of which is kept close to 4 per cent. Toward the end of the period of lactation (eighth or ninth month) the total solids, especially the fat and protein, may be increased considerably. Dry fodder does not further milk flow as well as green fodder, and often a

[1] In the preparation of this chapter I have made extensive use of Heineman's book, "Milk" (W. B. Saunders Co., 1919), especially as regards the section on bacteriology, also of Sommerfeld's "Handbuch der Milchkunde," Wiesbaden, 1909.

change from the stable to the pasture in the spring increases the total amount of milk, and its content of solids as well. Increased exercise and more sunshine also probably partly account for this change.

Reaction.—The reaction of fresh cow's milk is amphoteric, that is, it turns red litmus blue and blue litmus red. On standing, the reaction soon becomes acid, owing to the lactic acid that is produced from bacterial decomposition of the milk-sugar. Cow's milk, as ordinarily used, is, therefore, more acid than human milk.

Physical Properties.—The freezing-point of cow's milk is from —.54 to —57° C., the boiling-point about 101° C. Its specific gravity is from 1.027 to 1.034. It is more opaque than human milk, owing to the larger amount of calcium casein that it contains. It is likely to be more yellow in color when the cows are taking considerable green fodder. This pigment is contained in the fat, and is derived from the carotin and xanthophyll present in most chlorophyl containing vegetable matter. The milk of different animals and, indeed, of different cows has different creaming properties. This is probably due largely to the size of the fat globules; the cream of a milk with large fat globules, such as Jersey milk, rises much more rapidly than the cream of a milk with small fat globules, probably due to the fact that the emulsion with large globules is not so perfect, and therefore allows them to become separated from the rest of the milk more easily. Goat's milk, which has very small fat globules (3 to 4.5 microns), does not cream at all, and human milk, in which the majority of fat globules are probably smaller than those in cow's milk, does not cream as readily as cow's milk. Milk which has been boiled is also very slow in creaming, and milk which has been "homogenized" by mechanically breaking up the large fat globules into smaller ones does not cream at all. The fat globules rise more rapidly in fresh than in old milk, and more slowly in cold than in warm milk.

Fat.—The fat exists in milk in the form of an emulsion of fat globules. They usually measure from 0.0016 to

0.01 mm. in diameter, but may vary a good deal in size according to the breed of the cow. Those of Jersey milk are larger than those in the milk of any other breed. There is no relationship, however, between the size of the fat globules and the richness of milk. According to Eckles and Shaw there is no appreciable difference in the nature of the fat of different breeds, except as regards the size of the globules. The amount of fat, however, may vary considerably with the breed, as shown in the following table by Van Slyke and Publow (cited by Heineman):

Breed.	Fat percentages.
Holstein-Friesian	3.26
Ayreshire	3.76
American Holderness	4.01
Shorthorn	4.28
Devon	4.89
Guernsey	5.38
Jersey	5.78

Butter fat is more complicated in composition than most other animal or vegetable fats. It consists chemically of glycerin in combination with a number of fatty acids, forming a so-called "triglycerid" or "ester." The acids which are found in the fat of cow's milk in combination with glycerin are many, in the following proportions:

Acids.	Percentage.
Butyric, caproic, caprylic, and capric acids	6.3
Myristic, palmitic, and stearic acids	49.46
Oleic acid	36.10
Glycerol	12.54

Some of these acids are solids at ordinary temperature, and are non-irritating to the digestive tract; some, such as butyric, are liquids, very volatile, and more irritating. The acids in butter fat may then be divided into the volatile (irritating) and non-volatile (non-irritating) groups. Of the total fatty acid content of cow's milk fat about 15 per cent. are of the volatile, irritating group (5 to 27 per cent., according to different

observers). Of these volatile acids, butyric is probably the most important. This high content in volatile acid may be of considerable practical importance in infant feeding, as will be seen later.

Lactose is the sugar found in the milk of all mammals. It is a disaccharid, that is, a sugar consisting of two molecules of a simpler sugar, or monosaccharid. The amount of lactose varies but little in the milk of different cows. The lactose in cow's milk is identical with that in human milk.

Protein.—The proteins in cow's milk are casein, lactalbumin, lactoglobulin, and opalisin. The only two that exist in amounts sufficient to be of any importance are casein and lactalbumin.

Casein is a phosphorus-containing protein of complex chemical composition. It is insoluble in water and exists in milk in the form of a suspension. It does not coagulate on boiling, but is easily precipitated by weak acids and by rennin. It is coagulated in the stomach by the action of the gastric juices into a tough leathery curd.

Lactalbumin belongs to a different group of proteins than casein, and is somewhat similar to egg-albumen. It is soluble in water, is not coagulated by acids or by rennin, but is coagulable by heat at about 72° to 80° C.

Cow's milk contains about 3 per cent. of casein and 0.50 per cent. of lactalbumin.

Salts.—The most striking thing about the ash of cow's milk is its high calcium content in the form of insoluble dicalcium phosphate. According to Langstein and Meyer[1] 1000 gm. of cow's milk contain the following:

K_2O	1.77 gm.
Na_2O	0.46 gm.
CaO	1.72 gm.
MgO	0.20 gm.
Fe_2O_3	0.0004–0.0007 gm.
Cl	0.82 gm.
P_2O_5	2.06–2.43 gm.
	7.55 gm.

[1] Säuglingsernährung und Säuglingsstoffwechsel, Wiesbaden, 1914.

According to Bosworth and Van Slyke[1] these salts are arranged as follows:

	Percentage.
Sodium chlorid	10.6
Potassium chlorid	9.1
Monopotassium phosphate	12.7
Dipotassium phosphate	9.2
Potassium citrate	5.4
Dimagnesium phosphate	3.7
Magnesium citrate	4.0
Dicalcium phosphate	7.4
Tricalcium phosphate	8.9
Calcium citrate	23.5
Calcium oxid (caseinate)	5.1

In solution are the salts of potassium, sodium, chlorin, citric acid, and some of the phosphates, calcium, and magnesium salts. The di- and triphosphates are in suspension and do not pass through a porcelain filter.

Ferments.—Cow's milk contains a number of enzymes or ferments, proteolytic, carbohydrate splitting, oxidizing, and reducing. Little is known about the action of these enzymes, or whether they are of any particular value in the nutrition of the infant. Their activity is seriously affected by heat at 70° C. and they are destroyed at 80° C.

Vitamins.—(See chapter on Scurvy.)

Cells.—Cow's milk contains moderate numbers of epithelial cells and sometimes leukocytes or red blood-corpuscles derived from the circulation. If leukocytes are in excess, disease of the udder should be suspected.

The Bacteriology of Milk.—The most important sources of the bacteria in cow's milk are:

1. Manure and dirt about the cows.
2. Dust and dirt in the barn.
3. Dirty utensils.
4. Hands of the milker.

Milk is one of the best of culture-media for bacteria, and consequently dirty milking methods favor the growth of an

[1] Jour. Biol. Chem., vol. xxiv, No. 31,916.

enormous and varied flora. Even with clean milking methods it is extremely difficult to keep down bacterial growth within reasonable limits. A clean milk suitable for infant feeding should contain a maximum of not over 10,000 bacteria per cubic centimeter. Ordinary market milk should be kept below 100,000 per cubic centimeter. Most of the bacteria found in milk are saprophytes, and are harmless for adults. This does not hold true for babies, however, and milk infected with large numbers of saprophytic organisms is probably one of the greatest causes of infant mortality that there is. As regards infant feeding it is not the typhoid bacillus, etc., which may occasionally occur in milk that we are especially interested in, but these ordinary saprophytic bacteria. They do not attack the baby in the sense of invading his tissues, but attack the food in his intestines, and either ferment or putrefy it, forming irritating end-products which may bring about severe nutritional disturbance.

The saprophytic organisms in milk may be classified as follows (Heineman):

1. Lactic acid bacteria.
2. Spore-bearing bacteria.
3. Bacteria causing abnormal conditions in milk (pigmentation, etc.).
4. Molds and yeasts.

1. The *lactic acid organisms* include three groups—the Bacillus aërogenes, the Streptococcus lacticus, and the lactobacilli.

The first two types are practically always present in market milk, and are the ones which cause ordinary souring. The Streptococcus lacticus is the most important and most frequent in occurrence of all the lactic acid products. In nature this organism is widely distributed in plants and cultivated lands, in dust, manure, or hay. Its occurrence in cow manure explains its constant presence in milk. The lactobacilli are the ones chiefly used in the production of sour fermented milk (lactic acid milk, Bulgarian milk, etc.). There are many varieties, but they are all closely related. They are large Gram-positive

bacilli, and produce large amounts of lactic acid in milk, sometimes up to 3 per cent. The most important members of the group are the Bacillus bulgaricus, B. acidophilus, B. bifidus, and Boas-Oppler bacillus.

2. *Spore-bearing Bacteria.*—Milk practically always contains moderate numbers of spore-bearing bacteria. These consist of the Bacillus proteus, members of the hay bacillus group, the bacillus of Flügge, the gas bacillus (Bacillus aërogenes capsulatus), and others. Some of these are organisms which attack protein and cause putrefaction of the milk. Others have the power of producing butyric or propionic acid from milk-sugar. The protein-splitting bacteria ("peptonizers") are not present in such large numbers as the lactic acid bacilli, and their growth, as a rule, is not particularly easy, as they are crowded out by the numerous lactic acid bacilli present, and also inhibited to a certain extent by the lactic acid which is formed.

3. *Bacteria Causing Special Abnormal Conditions in Milk.*—Certain bacteria may produce pigments which cause color changes in milk. Most of the pigments are of no pathologic significance. Other bacteria may produce slimy, stringy, or ropy milk. Still others may cause a very noticeable bitter taste to appear.

Blue Milk.—Blue is the most common abnormal color. Bacillus cyanogenes is the most common cause of it, and, according to Weigmann, may be produced by feeding turnips or clover mixed with horsetail which contains the characteristic bacillus.

Red Milk.—A red color may occasionally appear in stale milk, and is usually due to the Bacillus prodigiosus.

Slimy and Stringy Milk.—In stringy milk the consistency of the milk is changed so that it can be drawn out into threads, sometimes to a length of several feet (Heineman). Slimy or stringy milk may be caused by certain slime-forming bacteria, or by disease of the udder in some cases. Occasionally certain strains of the Streptococcus lacticus may produce slimy milk, but the chief cause of it is the Bacillus lactis viscosi. This

organism is found in nature or the surfaces of stagnant pools, and cows carry it on their legs after they have been in wading. It grows preferably at low temperature, even as low as that of an ice-chest, and when it is once introduced into a dairy it is very hard to get rid of.

Bitter milk is caused by the formation of peptones from the milk protein by certain peptonizing bacteria (usually cocci) which have the power to attack it, or by feeding certain foods to the cow, such as lupine, turnips, or cabbages.

4. *Molds* and *yeasts* are present in all milks, and are especially noticeable in very old milks. Some of them have the power of attacking protein, some carbohydrate.

The Souring of Milk.—The kind of decomposition that occurs in milk depends largely upon the predominating kinds of organisms, and the temperature at which it is kept. The bacterial flora of milk practically always includes lactic acid organisms, and these usually multiply at such a rate as to outstrip all others. They attack the milk-sugar and produce lactic acid from it. When the degree of acidity becomes sufficient the protein is precipitated ("curdling"). The acidity of milk does not usually increase until several hours after milking, and then the increase is rapid. As the acid increases the growth of the proteolytic bacteria is inhibited, and the lactic acid organisms multiply at an extraordinary rate, so that soon enough acid is produced to restrain the growth of the proteolytic bacteria entirely. When the acid content becomes high, molds and yeasts, which prefer an acid medium, begin to multiply, the molds attack chiefly the protein, and by protein decomposition the acid is gradually neutralized. By degrees the acid disappears entirely, and the proteolytic bacteria, having survived as spores, begin to multiply, producing protein cleavage products, and a putrid milk results. In some milks the number of lactic acid bacteria is very low, and the protein-splitting types may obtain an early foothold. In such cases the milk putrefies before enough acid is formed to check the putrefying bacteria.

According to Bosworth and Van Slyke[1] the following chemical changes take place in sour milk:

1. About 22 per cent. of the milk-sugar is changed by the lactic acid bacteria, 88.5 per cent. of this being converted into lactic acid.

2. Citric acid completely disappears from the milk, being decomposed into acetic acid and carbon dioxid.

3. The insoluble inorganic constituents (dicalcium phosphate) of the fresh milk are made soluble by the lactic acid.

4. The calcium casein present in the fresh milk is changed into free protein and precipitated, the calcium forming lactate.

It has been said that pasteurized milk putrefies instead of souring, because the lactic acid bacilli are killed by pasteurization, whereas the spore-bearing peptonizing bacteria are not. This has been disproved by Ayers and Johnson,[2] who arrived at the following conclusions:

1. Pasteurized milk always sours because of the development of lactic acid bacteria, which on account of their high thermal death-point survive pasteurization. The acid development in an efficiently pasteurized milk is about the same as that in a clean raw milk.

2. The relative proportion of the groups of peptonizing and lactic acid bacteria is about the same in efficiently pasteurized milk as it is in clean raw milk.

3. The number of peptonizers in a good grade of pasteurized milk on the initial count and on succeeding days is approximately the same as in clean raw milk under similar temperature conditions.

Milk also may contain a number of true pathogenic organisms which produce specific diseases. These, as a rule, get into the milk either from a diseased cow, from an infected milker, or from water used in washing milk-pails or bottles (typhoid).

Streptococci.—The most common causes of pathogenic

[1] Jour. Biochem., 24, 191, March, 1916.

[2] Bureau of Animal Industry, Bull. 126, 1910.

streptococci in milk are mastitis ("garget") in the cow, or streptococcic infection of the throat of the milker.

Mastitis or "garget" is a very common condition. It is an inflammation of the udder, either acute or chronic, due in most instances to a streptococcus. In certain cases, particularly in the early stages, the most careful physical examination of the cow may fail to reveal it. Later the inflammatory condition becomes evident. It is, therefore, a most insidious condition, as despite the most careful precautions a cow in even a certified milk herd may have mastitis and pathogenic streptococci may have been occurring in the milk for several days before anything wrong with the cow is noticed.

Milk from a cow suffering with mastitis if it contains pus may appear thick and yellowish, and after standing a yellowish sediment may separate out. The heat-coagulable albumin is likely to increase considerably, while the casein diminishes. The reaction is likely to be alkaline. The number of leukocytes in the sediment of the milk is greatly increased, and a large number of leukocytes plus chains of streptococci are important points in diagnosing a mastitis milk. The difficulty is that practically all market milk contains the Streptococcus lacticus, which is an organism non-pathogenic for man or for cows, and it may be very difficult indeed even for a competent bacteriologist to distinguish between the various types of streptococci and to tell which are harmful and which are not. Probably many reports of finding the Streptococcus pyogenes in milk from apparently healthy udders really mean the presence of Streptococcus lacticus.

Not a few epidemics of so-called septic sore throat have been traced to a milk supply infected with virulent streptococci from a milker with tonsillitis. In some cases an epidemic has assumed serious proportions, and fatal generalized streptococcus sepsis has followed the initial throat infection. In the 1915 Boston epidemic over 2000 persons were affected.

Tuberculosis.—Many cows are infected with tuberculosis, and the bovine tubercle bacillus is definitely pathogenic for

man, particularly for young babies and children. The bovine bacillus when taken through infected milk is more likely to cause glandular and abdominal tuberculosis than any other type. According to Pottenger[1] about 10 per cent. of all tuberculosis in human beings is due to the bovine bacillus. Heineman estimates that probably 10 per cent. of all dairy cows are tubercular, and Carpenter found in 1910 that of 421 herds in New York State tested by him, 302 contained cows reacting to the tuberculin test. The total number of cows tested was 9633, and of these, 3432 reacted. According to Heineman a conservative estimate might place the market milk infected with the tubercle bacillus at from 6 to 8 per cent. This is, in truth, a high percentage, but it is probable that many specimens of milk contain so few bacilli that they are destroyed in the stomach or pass through the digestive tract without doing any harm. None the less the danger to babies and young children from milk of tubercular cows is a real one, and it is undoubtedly true that a considerable number become infected with tuberculosis in this way.

If the trouble with the infected cow is tuberculosis of the udder, the bacilli get into the milk directly from that source in large numbers. If the trouble is pulmonary tuberculosis, the feces of the cow is probably the chief source of infection, as much tubercular material is swallowed, and there is always a not inconsiderable amount of cow manure in milk, unless the milking is done with the utmost care (see Standards for Certified Milk).

The Tuberculin Test.—This test is of very great value in detecting tuberculosis in cows, as it is almost impossible to detect it in the early stages by physical examination alone. In the later stages the cow develops symptoms such as diarrhea, loss of weight, cough, etc.

This test is usually considered a very accurate one, and according to various observers it is stated that it is correct in from 95 to 98 per cent. of all cases. The chief trouble with it

[1] Southern Med. Jour., 1915, vii, 935.

is that it does not distinguish between mild and severe forms of tuberculosis. A cow with a small tuberculous gland which could not by any possibility infect the milk supply is likely to give as marked a tuberculin reaction as one which is in an advanced stage of pulmonary tuberculosis. After a tuberculin test has been performed a cow, even if tubercular, will not react again for a period of about six weeks. This phenomenon has been often taken advantage of by unscrupulous dealers, who perform tuberculin tests on their cows just before they are offered for sale.

The tuberculin test is usually carried out as follows (Heineman):

The temperature of the cow is taken during the day every two or three hours, and the tuberculin is injected the evening of the same day. Beginning early the next morning the temperature is taken again at regular intervals. The temperatures of the day previous to and that following injections are plotted on a chart and the curves compared. If the maximum temperature after injection is 2 degrees or more above the normal, tuberculosis is indicated.

Other Diseases Transmitted by Milk.—Epidemics of dysentery, scarlet fever, typhoid fever, and diphtheria have many times been traced to infected milk supplies.

Preservatives in Milk (Formalin).—Although many chemical preservatives have been used by unscrupulous dealers in order to preserve old milk, formalin is by far the most common. If present in a dilution of 1 : 10,000 there is a marked restraining influence on bacterial growth, and in a dilution of 1 : 40,000 it also probably prevents it to a certain extent. In this dilution there is a question whether it is harmful or not, but while the occasional ingestion of small amounts of formalin might do no harm, it is conceivable that in long-continued doses it might.

Detection of Formaldehyd (Hehner's Test).—Place 5 c.c. of the milk in a test-tube and pour about 3 c.c. of commercial concentrated sulphuric acid slowly down the side of the tube so that the liquids do not mix. At the junction of the liquids

a violet zone appears in the presence of formaldehyd. If pure sulphuric acid is used, a few crystals of ferrous sulphate should be added to the acid, as iron is a necessary ingredient for this test.

Frozen Milk.—In severe winters milk is often delivered in a frozen condition, and mothers are in doubt as to whether it should be used. My own opinion is that it should not be used if any other can be obtained, as I have seen it apparently cause severe vomiting in a few babies. In others it appears to do no harm. Mixsell,[1] in an excellent article on frozen milk, quoted below, says he has personally seen no ill effects from its use, but advises against it, as there are so many differences of opinion regarding it. The freezing-point of milk is about 55° C. The water freezes at first in proximity to the wall of the jar; the solids are forced toward the center, where a more concentrated solution is formed, which freezes only at lower temperatures. The chemical action of freezing on the fat and on the lactose is slight; the protein is split into peptones and eventually into amino-acids, but this occurs only after a period of two weeks or more. Freezing does not destroy the pathogenic bacteria, and milk kept very cold does not sour, but turns putrid, because the lactic acid bacteria do not grow at low temperature, while the putrefying organisms do. Thawed milk is never exactly the same as milk which has not been frozen. The natural emulsion of fat is never restored after freezing, and the casein is likely to appear in flakes rather than in its original colloidal condition. If frozen cream is added to coffee the fat of the cream does not mix homogeneously, but rises on the surface in large oily, yellow globules. The probable reason why milk which has been frozen upsets some babies is that the fat is rendered more difficult of digestion owing to the breaking up of its emulsion.

CERTIFIED MILK

The term "certified milk" was first introduced by the late Dr. Coit, of Newark, New Jersey, *and simply means a clean,*

[1] Arch. Ped., vol. xxxvii, No. 5, 1920.

raw milk produced under the most careful conditions, which is certified by a medical milk commission to measure up to the standards set by the Association of Medical Milk Commissions. The production of clean milk is the first and fundamental step in infant feeding, and it is so important for the physician to understand the conditions under which such milk is produced that I have included (copied from Heineman) the more important portions of the rules adopted by the American Association of Medical Milk Commissions for the production of certified milk.

Standards for Certified Milk

Hygiene of the Dairy.—1. *Pastures* or *paddocks* to which the cows have access shall be free from marshes or stagnant pools, crossed by no stream which might become dangerously contaminated, at sufficient distances from offensive conditions to suffer no bad effects from them, and shall be free from plants which affect the milk deleteriously.

2. *Surroundings of Buildings.*—The surroundings of all buildings shall be kept clean and free from accumulations of dirt, rubbish, decayed vegetable or animal matter or animal waste, and the stable yard shall be well drained.

3. *Location of Buildings.*—Buildings in which certified milk is produced and handled shall be so located as to insure proper shelter and good drainage and at sufficient distance from other buildings, dusty roads, cultivated and dusty fields, and all other possible sources of contamination; provided, in the case of unavoidable proximity to dusty roads or fields, the exposed side shall be screened with cheese-cloth.

4. *Construction of Stables.*—The stables shall be constructed so as to facilitate the prompt and easy removal of waste products. The floors and platforms shall be made of cement or other non-absorbent material and the gutters of cement only. The floors shall be properly graded and drained, and the manure gutters shall be from 6 to 8 inches deep and so placed in relation to the platform that all manure will drop into them.

5. The inside surface of the walls and all interior construc-

tion shall be smooth, with tight joints, and shall be capable of shedding water. The ceiling shall be of smooth material and dust-tight. All horizontal and slanting surfaces which might harbor dust shall be avoided.

6. *Drinking and Feed Troughs.*—Drinking troughs or basins shall be drained and cleaned each day, and feed troughs and mixing floors shall be kept in a clean and sanitary condition.

7. *Stanchions,* when used, shall be constructed of iron pipes or hard wood, and throat latches shall be provided to prevent the cows from lying down between the time of cleaning and the time of milking.

8. *Ventilation.*—The cow stables shall be provided with adequate ventilation either by means of some approved artificial device, or by the substitution of cheese-cloth for glass in the windows, each cow to be provided with a minimum of 600 cubic feet of air space.

9. *Windows.*—A sufficient number of windows shall be installed and so distributed as to provide satisfactory light and a maximum of sunshine, 2 feet square of window area to each 600 cubic feet of air space to represent the minimum. The coverings of such windows shall be kept free from dust and dirt.

10. *Exclusion of Flies, etc.*—All necessary measures should be taken to prevent the entrance of flies and other insects and rats and other vermin into all the buildings.

11. *Exclusion of Animals from the Herd.*—No horses, hogs, dogs, or other animals or fowls shall be allowed to come in contact with the certified herd, either in the stables or elsewhere.

12. *Bedding.*—No dusty or moldy hay or straw, bedding from horse stalls, or other unclean materials shall be used for bedding the cows. Only bedding which is clean, dry, and absorbent may be used, preferably shavings or straw.

13. *Cleaning Stable and Disposal of Manure.*—Soiled bedding and manure shall be removed at least twice daily, and the floors shall be swept and kept free from refuse. Such cleaning shall be done at least one hour before the milking time. Manure,

when removed, shall be drawn to the field or temporarily stored in containers so screened as to exclude flies. Manure shall not be even temporarily stored within 300 feet of the barn or dairy building.

14. *Cleaning of Cows.*—Each cow in the herd shall be groomed daily, and no manure, mud, or filth shall be allowed to remain upon her during milking; for cleaning, a vacuum apparatus is recommended.

15. *Clipping.*—Long hairs shall be clipped from the udder and flanks of the cow and from the tail above the brush. The hair on the tail shall be cut so that the brush may be well above the ground.

16. *Cleaning of Udders.*—The udders and teats of the cow shall be cleaned before milking; they shall be washed with a cloth and water, and dry wiped with another clean sterilized cloth—a separate cloth for drying each cow.

17. *Feeding.*—All food-stuffs shall be kept in an apartment separate from and not directly communicating with the cow barn. They shall be brought into the barn only immediately before the feeding hour, which shall follow the milking.

18. Only those foods shall be used which consist of fresh, palatable, or nutritious materials, such as will not injure the health of the cows or unfavorably affect the taste or character of the milk. Any dirty or moldy food or food in a state of decomposition or putrefaction shall not be given.

19. A well-balanced ration shall be used, and all changes of food shall be made slowly. The first feedings of grass, alfalfa, ensilage, green corn, or other green feeds shall be given in small rations and increased gradually to full rations.

20. *Exercise.*—All dairy cows shall be turned out to exercise at least two hours in each twenty-four in suitable weather. Exercise yards shall be kept free from manure and other filth.

21. *Washing of Hands.*—Conveniently located facilities shall be provided for the milkers to wash in before and during milking.

22. The hands of the milkers shall be thoroughly washed with soap, water and brush, and carefully dried on a clean towel

immediately before milking. The hands of the milkers shall be rinsed with clean water and carefully dried before milking each cow. The practice of moistening the hands with milk is forbidden.

23. *Milking Clothes.*—Clean overalls, jumper, and cap shall be worn during milking. They shall be washed or sterilized each day and used for no other purpose, and when not in use they shall be kept in a clean place, protected from dust and dirt.

24. *Things to be Avoided by Milkers.*—While engaged about the dairy or in handling the milk employees shall not use tobacco or intoxicating liquors. They shall keep their fingers away from their noses and mouths, and no milker shall permit his hands, fingers, lips, or tongue to come in contact with milk intended for sale.

25. During milking the milkers shall be careful not to touch anything but the clean top of the milking stool, the milk pail, and the cow's teats.

26. Milkers are forbidden to spit upon the walls or floors of stables, or upon the walls or floors of milk houses, or into the water used for cooling the milk or washing the utensils.

27. *Fore-milk.*—The first streams from each teat shall be rejected, as this fore-milk contains large numbers of bacteria. Such milk shall be collected into a separate vessel and not milked on to the floors or into the gutters. The milking shall be done rapidly and quietly, and the cows shall be treated kindly.

28. *Milk and Calving Period.*—Milk from all cows shall be excluded for a period of forty-five days before and seven days after parturition.

29. *Bloody and Stringy Milk.*—If milk from any cow is bloody and stringy or of unnatural appearance, the milk from that cow shall be rejected and the cow isolated from the herd until the cause of such abnormal appearance has been determined and removed, special attention being given in the meantime to the feeding or to possible injuries. If dirt gets into the pail, the milk shall be discarded and the pail washed before it is used.

30. *Make-up of Herd.*—No cows except those receiving the same supervision and care as the certified herd shall be kept in the same barn or brought in contact with them.

31. *Employees Other than Milkers.*—The requirements for milkers, relative to garments and cleaning of hands, shall apply to all other persons handling the milk, and children unattended by adults shall not be allowed in the dairy nor in the stable during milking.

32. *Straining and Strainers.*—Promptly after the milk is drawn it shall be removed from the stable to a clean room and then emptied from the milk pail to the can, being strained through strainers made of a double layer of finely meshed cheese-cloth or absorbent cotton thoroughly sterilized. Several strainers shall be provided for each milking in order that they may be frequently changed.

33. *Dairy Building.*—A dairy building shall be provided which shall be located at a distance from the stable and dwelling prescribed by the local commission, and there shall be no hog-pen, privy, or manure pile at a higher level or within 300 feet of it.

34. The dairy building shall be kept clean and shall not be used for purposes other than the handling and storing of milk and milk utensils. It shall be provided with light and ventilation, and the floors shall be graded and water-tight.

35. The dairy building shall be well lighted and screened and drained through well-trapped pipes. No animals shall be allowed therein. No part of the dairy building shall be used for dwelling or lodging purposes, and the bottling room shall be used for no other purpose than to provide a place for clean milk utensils and for handling the milk. During bottling this room shall be entered only by persons employed therein. The bottle room shall be kept scrupulously clean and free from odors.

36. *Temperature of Milk.*—Proper cooling to reduce the temperature to 45° F. shall be used, and aërators shall be so situated that they can be protected from flies, dust, and odors.

The milk shall be cooled immediately after being milked, and maintained at a temperature between 35° and 45° F. until delivered to the consumer.

37. *Sealing of Bottles.*—Milk after being cooled and bottled shall be immediately sealed in a manner satisfactory to the commission, but such seal shall include a sterile hood which completely covers the lip of the bottle.

38. *Cleaning and Sterilizing of Bottles.*—The dairy building shall be provided with approved apparatus for the cleansing and sterilizing of all bottles and utensils used in milk production. All bottles and utensils shall be thoroughly cleaned by hot water and sal soda, or equally pure agent, rinsed until the cleaning water is thoroughly removed, then exposed to live steam or boiling water at least twenty minutes, and then kept inverted until used, in a place free from dust and other contaminating materials.

39. *Utensils.*—All utensils shall be so constructed as to be easily cleaned. The milk pail should preferably have an elliptic opening 5 by 7 inches in diameter. The cover of this pail should be so convex as to make the entire interior of the pail visible and accessible for cleaning. The pail shall be made of heavy seamless tin, and with seams which are flushed and made smooth by solder. Wooden pails, galvanized-iron pails, or pails made of rough, porous materials are forbidden. All utensils used in milking shall be kept in good repair.

40. *Water-supply.*—The entire water-supply shall be absolutely free from contamination, and shall be sufficient for all dairy purposes. It shall be protected against flood or surface drainage and shall be conveniently situated in relation to the milk house.

41. *Privies, etc., in Relation to Water-supply.*—Privies, pigpens, manure piles, and all other possible sources of contamination shall be so situated on the farm as to render impossible the contamination of the water-supply, and shall be so protected by use of screens and other measures as to prevent their becoming breeding ground for flies.

42. *Toilet Rooms.*—Toilet facilities for the milkers shall be provided and located outside of the stable or milk house. These toilets shall be properly screened, shall be kept clean, and shall be accessible to wash basins, water, nail-brush, soap and towels, and the milkers shall be required to wash and dry their hands immediately after leaving the toilet room.

43. *Transportation.*—In transit the milk packages shall be kept free from dust and dirt. The wagon, trays, and crates shall be kept scrupulously clean. No bottles shall be collected from houses in which communicable diseases prevail, unless a separate wagon is used and under conditions prescribed by the department of health, and the medical milk commission.

44. All certified milk shall reach the consumer within thirty hours after milking.

Veterinary Supervision of the Herd.—45. TUBERCULIN TEST.—The herd shall be free from tuberculosis, as shown by the proper application of the tuberculin test. The test shall be applied in accordance with the rules and regulations of the United States Government, and all reactors shall be removed immediately from the farm.

46. No new animals shall be admitted to the herd without first having passed a satisfactory tuberculin test, made in accordance with the rules and regulations mentioned; the tuberculin to be obtained and applied only by the official veterinarian of the commission.

47. Immediately following the application of the tuberculin test to a herd for the purpose of eliminating tuberculous cattle, the cow stable and exercising yards shall be disinfected by the veterinary inspector in accordance with the rules and regulations of the United States Government.

48. A second tuberculin test shall follow each primary test after an interval of six months, and shall be applied in accordance with the rules and regulations mentioned. Thereafter, tuberculin tests shall be reapplied annually, but it is recommended that the retests be applied semi-annually.

49. *Identification of Cows.*—Each dairy cow in each of the

certified herds shall be labeled or tagged with a number or mark which shall permanently identify her.

50. *Herd-book Record.*—Each cow in the herd shall be registered in a herd book, which register shall be accurately kept so that her entrance and departure from the herd and her tuberculin testing can be identified.

51. A copy of this herd-book record shall be kept in the hands of the veterinarian of the medical milk commission under which the dairy farm is operating, and the veterinarian shall be made responsible for the accuracy of this record.

52. *Dates of Tuberculin Tests.*—The dates of the annual tuberculin tests shall be definitely arranged by the medical milk commission, and all of the results of such tests shall be recorded by the veterinarian and regularly reported to the secretary of the medical milk commission issuing the certificate.

53. The results of all tuberculin tests shall be kept on file by each medical milk commission, and a copy of all such tests shall be made available to the American Association of Medical Milk Commission for statistical purposes.

54. The proper designated officers of the American Association of Medical Milk Commission should receive copies of reports of all of the annual, semi-annual, and other official tuberculin tests which are made and keep copies of the same on file and compile them annually for the use of the association.

55. *Disposition of Cows Sick with Diseases Other than Tuberculosis.*—Cows having rheumatism, leukorrhea, inflammation of the uterus, severe diarrhæa, or disease of the udder, or cows that from any other cause may be a menace to the herd shall be removed from the herd and placed in a building separate from that which may be used for the isolation of cows with tuberculosis, unless such building has been properly disinfected since it was last used for this purpose. The milk from such cows shall not be used nor shall the cows be restored to the herd until permission has been given by the veterinary inspector after a careful physical examination.

56. *Notification of Veterinary Inspector.*—In the event of

the occurrence of any of the diseases just described between the visits of the veterinary inspector, or if at any time a number of cows become sick at one time in such a way as to suggest the outbreak of a contagious disease or poisoning, it shall be the duty of the dairyman to withdraw such sickened cattle from the herd, to destroy their milk, and to notify the veterinary inspector by telegraph or telephone immediately.

57. *Emaciated Cows.*—Cows that are emaciated from chronic disease or from any cause that in the opinion of the veterinary inspector may endanger the quality of the milk, shall be removed from the herd.

Bacteriologic Standards.—58. Bacterial Counts.—Certified milk shall contain less than 10,000 bacteria per cubic centimeter when delivered. In case a count exceeding 10,000 bacteria per cubic centimeter is found, daily counts shall be made, and if normal counts are not restored within ten days the certificate shall be suspended.

59. Bacterial counts shall be made at least once a week.

60. Collection of Samples.—The samples to be examined shall be obtained from milk as offered for sale and shall be taken by a representative of the milk commission. The samples shall be received in the original packages, in properly iced containers and they shall be so kept until examined, so as to limit as far as possible changes in their bacterial content.

61. The fat standard for certified milk shall be 4 per cent., with a permissible range of variation of from 3.5 to 4.5 per cent.

Methods and Regulations for the Medical Examination of Employees, Their Health and Personal Hygiene

62. A medical officer, known as the attending dairy physician, shall be selected by the commission, who should reside near the dairy producing certified milk. He shall be a physician in good standing and authorized by law to practice medicine; he shall be responsible to the commission and subject to its direction. In case more than one dairy is under the control of the commission and they are in different localities, a separate

physician should be designated for employment for the supervision of each dairy.

63. Before any person shall come on the premises to live and remain as an employee, such person, before being engaged in milking or the handling of milk, shall be subjected to a complete physical examination by the attending physician. No person shall be employed who has not been vaccinated recently or who upon examination is found to have a sore throat, or to be suffering from any form of tuberculosis, venereal disease, conjunctivitis, diarrhæa, dysentery, or who has recently had typhoid fever or is proved to be a typhoid carrier, or who has any inflammatory disease of the respiratory tract or any suppurative process or infectious skin eruption, or any disease of an infectious or contagious nature, or who has recently been associated with children sick with contagious disease.

64. In addition to ordinary habits of personal cleanliness all milkers shall have well-trimmed hair, wear close-fitting caps, and have clean shaven faces.

65. When the milkers live upon the premises their dormitories shall be constructed and operated according to plans approved by the commission. A separate bed shall be provided for each milker and each bed shall be kept supplied with clean bedclothes. Proper bathing facilities shall be provided for all employees on the dairy premises, preferably a shower-bath, and frequent bathing shall be enjoined.

66. In case the employees live on the dairy premises a suitable building shall be provided to be used for the isolation and quarantine of persons under suspicion of having a contagious disease.

The following plan of construction is recommended:

The quarantine building and hospital should be one story high and contain at least two rooms, each with a capacity of about 6000 cubic feet and containing not more than three beds each, the rooms to be separated by a closed partition. The doors opening into the rooms should be on opposite sides of the building and provided with locks. The windows should be

barred and the sash should be at least 5 feet from the ground and constructed for proper ventilation. The walls should be of a material which will allow proper disinfection. The floor should be of painted or washable wood, preferably of concrete, and so constructed that the floor may be flushed and properly disinfected. Proper heating, lighting, and ventilating facilities should be provided.

67. In the event of any illness of a suspicious nature the attending physician shall immediately quarantine the suspect, notify the health authorities and the secretary of the commission, and examine each member of the dairy force, and in every inflammatory affection of the nose or throat occurring among the employees of the dairy, in addition to carrying out the above-mentioned program, the attending physician shall take a culture and have it examined at once by a competent bacteriologist approved by the commission. Pending such examination, the affected employee or employees shall be quarantined.

68. It shall be the duty of the secretary, on receiving notice of any suspicious or contagious disease at the dairy, at once to notify the committee having in charge the medical supervision of employees of the dairy farm upon which such disease has developed. On receipt of notice this committee shall assume charge of the matter, and shall have power to act for the commission as its judgment dictates. As soon as possible, thereafter, the committee shall notify the commission, through its secretary, that a special meeting may be called for ultimate consideration and action.

69. When a case of contagious disease is found among the employees of a dairy producing certified milk under the control of a medical milk commission, such employee shall be at once quarantined and as soon as possible removed from the plant, and the premises fumigated.

70. When a case of contagion is found on a certified dairy it is advised that a printed notice of the facts shall be sent to every householder using the milk, giving in detail the precautions taken by the dairyman under the direction of the com-

mission, and it is further advised that all milk produced at such dairy shall be heated at 145° F. for forty minutes, or 155° F. for thirty minutes, or 167° F. for twenty minutes, and immediately cooled to 50° F. These facts should also be part of the notice, and such heating of the milk should be continued during the accepted period of incubation for such contagious disease.

The following method of fumigation is recommended:

After all windows and doors are closed and the cracks sealed by strips of paper applied with flour paste, and the various articles in the room so hung or placed as to be exposed on all sides, preparations should be made to generate formaldehyd gas by the use of 20 ounces of formaldehyd and 10 ounces of permanganate of potash for every 1000 cubic feet of space to be disinfected.

For mixing the formaldehyd and potassium permanganate a large galvanized-iron pail or cylinder holding at least 20 quarts and having a flared top should be used for mixing therein 20 ounces of formaldehyd and 10 ounces of permanganate. A cylinder at least 5 feet high is suggested. The containers should be placed about in the rooms and the necessary quantity of permanganate weighed and placed in them. The formaldehyd solution for each pail should then be measured into a wide-mouthed cup and placed by the pail in which it is to be used.

Although the reaction takes place quickly, by making preparations as advised all the pails can be "set off" promptly by one person, since there is nothing to do but to pour the formaldehyd solution over the permanganate. The rooms should be kept closed for four hours. As there is a slight danger of fire, the reaction should be watched through a window or the pails placed on a non-inflammable surface.

71. Following a weekly medical inspection of the employees, a monthly report shall be submitted to the secretary of the medical milk commission on the same recurring date by the examining visiting physician.

THE COOKING OF MILK

In order to reduce the normal bacterial growth in milk and to kill pathologic organisms it is heated by one of two methods:

1. Pasteurization.
2. Boiling.

Let us see what is accomplished by each of these methods, and what their advantages and disadvantages are as regards infant feeding.

Pasteurization.—In pasteurization the milk is heated to a temperature considerably below the boiling-point and is kept at that temperature for a period of time. A number of different methods are used commercially, but the most common and most satisfactory one is known as the "holding" method, where the milk is heated to 140° F. (60° C.) and is kept at that temperature for twenty minutes. In the home milk can be efficiently pasteurized in an ordinary tin pail. The individual milk bottles are put into the pail and water is added so that the bottles will be well covered up to the necks. Then the water is heated up to 160° F. When this temperature is reached the pail is removed from the stove and a heavy blanket is put over it to keep the heat in. It is allowed to stand one-half hour; then it is rapidly cooled and is put on the ice. Rapid cooling is important after pasteurization or boiling, as slow cooling, with the temperature of the milk at blood heat for a considerable period of time, favors the development of bacteria from the spores which have not been killed by the heat. There are a number of very convenient small home pasteurizers on the market, one of the best of which is that devised by Freeman.

What Pasteurization Accomplishes.—By pasteurization the vast majority of all organisms except spore bearers are destroyed. Especially is it to be noted that pasteurization kills the tubercle bacillus, and all the other ordinary pathogenic bacteria found in milk. It has been commonly believed that the vitamins are not destroyed by pasteurization, but there is some evidence, according to Hess, to show that their efficiency may be considerably impaired, especially if the milk is rather old when

it is pasteurized, and if the pasteurization is continued more than the ordinary time. (See chapter on Scurvy.)

Pasteurized milk sours normally, as does uncooked milk, owing to the fact that some lactic acid bacteria of high thermal death-point practically always survive. Pasteurized milk naturally keeps longer than unpasteurized milk of the same grade. The commercial pasteurization of milk has undoubtedly accomplished much and is a practical necessity for the general milk supply of large cities.

Boiling.—Boiling is usually done in the home in either one of two ways:

Open Boiling in a Saucepan.—By this method the temperature of the milk reaches about 101° C. If the chief purpose of boiling is to render the casein curd more digestible, this is the best method to use, and the milk should be boiled vigorously for from three to five minutes. It is very likely to "boil over" and has to be watched and stirred constantly, so that ordinarily it is simpler to employ the second method, which requires less attention.

Boiling in a Double Boiler.—By this method the milk reaches a temperature of about 99° C. and does not actually "boil." For all practical purposes, however, it is "boiled milk." The bacterial content is reduced as efficiently as it is by the open method, but boiling in a double boiler is not so efficient in making a soft curd. The water is put into the double boiler cold, and the milk allowed to cook for ten or fifteen minutes after the water in the outer vessel has come to a boil. It is then taken from the stove, and the outer vessel filled with several changes of cold water so that the milk may cool as rapidly as possible.

Changes Produced by Boiling.—By boiling all bacteria are destroyed except the most hardy spores. When milk is boiled a thin scum forms on the surface of the milk. This is partly due to coagulated proteins (lactalbumin, lactoglobulin) and partly to drying of the milk constituents on the surface. This scum consists chemically of

Fatty matter	45.42 per cent.	
Casein and albuminoid material	50.86 "	
Ash	3.72 "	(Rosenau)

Fat.—The emulsion of fat is partly broken up, and there is coalescence of some of the fat globules. Cream does not rise as well on boiled milk as it does on raw or on pasteurized milk.

Sugar.—There is a caramelization or charring of a certain amount of the lactose. This does not usually take place to any extent below 120° C., which is never reached in ordinary boiling.

Protein.—The lactalbumin and lactoglobulin are coagulated. This begins at about 75° C.

The casein is rendered less easy of coagulation by rennin, and a soft and flocculent curd is formed in the stomach instead of a hard, tough curd.

Salts.—There is a precipitation in insoluble form of a portion of the calcium and magnesium salts, and a considerable part of the phosphates. According to Soldner[1] (quoted by Lane-Clayton) about a sixth of the total calcium content is precipitated in this way, which is not enough to greatly reduce the available calcium to any great extent, although, according to Bosworth,[2] it is precipitated in a form (insoluble calcium phosphate) which cannot be absorbed by the baby.

Taste.—A characteristic "cooked" taste and smell develops, which is probably due to the liberation of minute quantities of hydrogen sulphid.

Vitamins and Ferments.—Ferments are destroyed by boiling, as are true bacterial toxins. There may be, however, other toxic decomposition products present in stale milk, which are not destroyed by boiling. The antiscorbutic vitamin is rendered less efficient, and probably destroyed by prolonged boiling. The other two vitamins are apparently not affected.

Souring.—Boiled milk ordinarily does not sour. It putrefies, owing to the fact that all of the lactic acid forming bacteria have been destroyed.

[1] Landw. Versuchs, 1888, p. 35.

[2] Personal communication.

The advantages of boiled milk are obvious:

1. By a very simple procedure the milk is rendered practically sterile, and the dangers which go with a bacterially contaminated milk are at once done away with. This is of tremendous importance, and if physicians living in places where the milk supply is doubtful would only realize this they would not need to turn to condensed milk and proprietary foods in the summertime as so many do.

2. The casein curd is rendered soft and flocculent, so that the chances of disturbing the baby's digestion from difficulty of casein digestion is greatly diminished, and a greater concentration of milk can be taken than would be the case with raw milk.

The main disadvantages that have been attributed to boiled milk are these:

1. The antiscorbutic vitamin is impaired in efficiency, thus predisposing to scurvy.

2. It is possible that the calcium salts are rendered less available in boiled milk than in raw.

3. Boiled milk is somewhat more constipating than raw milk.

4. It has been said that boiled milk is less nutritious than raw milk.

5. It has been said that babies fed on boiled milk are more likely to develop rickets than those fed on raw milk.

6. The ferments are destroyed by boiling.

Let us consider critically how real these "disadvantages" are.

It is probably true that babies fed on boiled milk are more likely to develop scurvy than those fed on raw milk. In most of the investigations of scurvy that have been undertaken it has been found that more babies developing it have been fed on boiled milk than on any other one sort of diet. On the other hand, in Germany and France, where boiled milk is used almost exclusively, there is apparently no more scurvy than there is here, where more raw milk is used. Boiled milk is certainly not

the entire cause of scurvy, as babies may sometimes develop it when fed on raw cow's milk or even on the breast. Orange juice in sufficient quantities (1 ounce a day) is a practically sure prophylactic, and the dangers of scurvy in a baby who is being fed intelligently on a sufficient quantity of fresh boiled milk, with the addition of orange juice, are practically nil. The fact that some babies develop scurvy when fed on boiled milk without the addition of orange juice in sufficient quantity cannot be taken as an argument against boiled milk. I say "sufficient quantity" because I have seen a number of babies with scurvy who had been taking an insufficient quantity of orange juice—1 teaspoonful a day or less. It is true that a certain amount of the calcium salts present are precipitated in insoluble forms by boiling milk, and are thus probably made unavailable for the baby. But there is such a large excess of calcium salts present in cow's milk that it is probable there is enough left in available forms to supply the baby's needs. There are few exact investigations on record concerning this point, and it must remain more or less a matter of conjecture until more light is shed upon it. As regards rickets, it has been said that lack of available calcium and destruction of vitamins in boiled milk cause babies fed on it to develop rickets more often than those fed on raw milk. There is no positive evidence to support this. We do not know that the calcium balance in babies fed on boiled milk is affected unfavorably, nor has it ever been positively shown that lack of vitamins is the cause of rickets. Inasmuch as there is no exact experimental evidence to support this idea, we must rely on general clinical observation, and from my own experience and from that of my colleagues at the Children's Hospital I should say that babies fed on boiled milk were no more likely to develop rickets than those fed on raw milk.

It is true that in some cases boiled milk is somewhat constipating, but this constitutes no real disadvantage, as a slight amount of constipation does no harm and can be easily controlled. Boiled milk is just as nutritious as raw milk, as it has

been shown a number of times that the absorption of the food elements is not deleteriously affected by boiling. It is true that the ferments of milk are destroyed by boiling, but inasmuch as it is not known what place the ferments hold in nutrition or whether they are of any value, their destruction cannot count as an important argument against boiled milk.

We see, then, that there are very few tangible arguments against boiled milk; we really know practically nothing about the relationship of boiled milk to rickets, and can protect our babies easily against scurvy. These possible disadvantages of boiled milk certainly cannot outweigh that most important of all advantages—a milk free from harmful bacteria.

Raw Milk versus Boiled or Pasteurized Milk.—There are many differences of opinion as to whether milk for infant feeding should be used raw, boiled, or pasteurized. My own personal opinion is as follows: *No milk should be fed raw to infants or children under three years of age unless it is certified milk or of equal grade. During hot, muggy weather even certified milk should not be used raw, and in the South all milk for babies should be either boiled or pasteurized at all times, whether it is certified or not. Inasmuch as the amount of certified milk available comprises only about 1 per cent. of the total milk supply, most babies will have their milk cooked.*

Boiled versus Pasteurized Milk.—As far as the general milk supply is concerned, pasteurization is satisfactory. As regards infant feeding and the heating of milk in the home, boiling is so much more simple than pasteurization that most pediatrists have discarded the latter method, and although certain disadvantages have been supposed to go with boiled milk, these do not equal its advantages. In using market milk which has already been pasteurized in the winter there is no need to recook it in the home unless to make a softer casein curd; in the summer it should be reboiled.

Milk at Summer Resorts.—Most mothers who take their children away for the summer to the seashore or country worry a great deal about the milk supply, and often have their pet

milk sent each day from the city in special ice-boxes at considerable expense and trouble. There is no need of this. At almost any summer resort a farmer can be found who has reasonably good milk; this can be boiled as soon as it is delivered, and is likely to be a good deal better than any milk from the city, as it is very much fresher.

THE ESSENTIAL DIFFERENCES BETWEEN COW'S MILK AND HUMAN MILK

It is necessary, in order to understand the nutritional processes of babies fed on cow's milk, to have a clear idea of the essential points in which it differs chemically from human milk.

Fat.—The fats of the two milks differ considerably in their chemical nature. The fat of human milk contains only about 2 per cent. of the lower irritating volatile fatty acids, that of cow's milk contains anywhere from 6 to 27 per cent., according to different observers. It is possible that this high content in irritating acids, especially butyric and caproic, may have a good deal to do with the difficulty that some infants have in digesting cow's fat.

Of the more volatile acids, oleic makes up at least 50 per cent. of the total fatty acid content of human milk fat, whereas it makes up only 35 per cent. of the total content of cow's fat. Cow's milk fat contains a good deal more palmitin than does that of human milk. The calcium soaps of oleic acid are much more easily absorbed than those of palmitic acid. This may be another reason why the fat of human milk is tolerated better than that of cow's milk. The fat globules of human milk are probably in a much finer emulsion than in cow's milk. "When the number of droplets are counted in a counting chamber there are always more in human than in cow's milk. The fat globules in human milk measure between 0.001 and 0.02 mm., while those in cow's milk measure 0.0016 to 0.01 mm. Since the measurements given above show that the fat droplets in human milk may be of greater diameter than those in cow's milk, it seems inconsistent that there should be a larger number

in the former than in the latter. The explanation must be that the majority of fat droplets in human milk are small and measure about 0.001 mm., while the majority of those in cow's milk must be closer to the upper limit and measure nearly 0.01 mm."[1] The larger the number of fat globules, the greater the surface area for the fat-splitting ferments to work on, and, therefore, more complete digestion of the fat. This may be another reason why the fat of human milk is better as an infant food than that of cow's milk.

Protein and Salts.—Cow's milk contains over twice as much protein and over three times as much ash as does human milk. This is on account of the more rapid growth of the calf, which needs a large amount of protein and of salts in order to supply material for the rapid growth of bone and muscle tissue.

It is interesting to note that in most mammalia the ash and protein content of the milk of each species is in inverse proportion to the length of time needed for the young to double its birth weight.[2]

Species.	Period in which weight of newborn is doubled (days).	100 grams of milk contain Protein, gm.	Salt, gm.
Man	180	1.25	0.20
Horse	60	2.0	0.40
Cow	47	3.5	0.70
Goat	22	3.7	0.80
Sheep	15	4.9	0.80
Pig	14	5.2	0.80
Cat	9.5	7.0	1.0
Dog	9	7.4	1.3
Rabbit	6	10.4	2.50

Most of the protein in cow's milk is casein, in the proportion of about 6 parts of casein to 1 of lactalbumin. In human milk, according to most authors, the casein and lactalbumin are about equally divided.

Cow casein is probably not the same substance chemically that human casein is. Cow casein contains 0.87 per cent. of

[1] Morse and Talbot, "Infant Feeding and Diseases of Nutrition," 1915.

[2] Table by Proscher and Abderhalden (quoted by Hawk, Physiological Chemistry).

phosphorus, human casein only 0.25 per cent. Cow casein coagulates in the stomach in tough, leathery masses, human casein in fine flakes.

The salt content of cow's milk is greatly in excess of that of human milk, and although we know as yet relatively little regarding the metabolism of the salts and their effect in producing disturbances of digestion or of nutrition, it is undoubtedly true that the large amount of inorganic material, particularly salts of calcium, of sodium, and of phosphorus, and the forms in which they are found, have a great deal to do with some of the disturbances in babies fed on cow's milk. Cow's milk is, however, much poorer in iron than human milk, and this, too, has an important bearing on practical infant feeding, because babies fed too long on milk, without other iron-containing food are likely to become anemic and flabby.

Salt Content of Human and Cow's Milk (Langstein and Meyer)

1000 grams of ash contains:

	Human.	Cow.
K_2O,	0.69 gm.	1.885 gm.
Na_2O,	0.16 "	0.465 "
CaO,	0.42 "	1.72 "
MgO,	0.068 "	0.205 "
Fe_2O_3,	0.001–0.004 gm.	0.0004–0.0007 gm.
Cl,	0.294 gm.	0.820 gm.
SO_3,	0.143 "	..... "
P_2O_5,	0.249–.0418 gm.	2.065–2.437 gm.
	1.988 gm.	7.553 gm.

The high salt content is important in relation to the fat digestion also, as it probably favors the formation of insoluble calcium soaps, which are difficult of absorption.

To sum up:

1. There are important physical and chemical differences between the fats in the two milks, which indicate that the fat of cow's milk would be digested and absorbed with more difficulty than that of human milk.

2. The total protein is considerably higher in cow's milk. This is due to the large amount of casein in cow's milk. It is

a different substance chemically from that in human milk, and is probably digested with more difficulty.

3. The salt content of cow's milk is very high in comparison with that of human milk. This would seem to be of especial importance as regards the calcium salts, the large excess of which probably has a good deal to do with disturbances of fat metabolism.

With these differences in mind it is not hard to see why the metabolic processes of breast-fed and artificially fed babies are very different, and why there is so much possibility for a totally different category of digestive and nutritional disturbances to develop in the artificially fed than in the breast-fed infant.

CHAPTER VII

THE MODIFICATION OF MILK[1]

By the "modification" of milk is meant changing the composition of the original cow's milk in order to make it suitable for the digestion of the particular infant that is being fed. It is possible to successfully feed some babies on undiluted cow's milk, but these babies represent a very small minority, and for practical purposes it may be said that it is always necessary to modify cow's milk before it is fed to young babies. In the past fifty years there have been proposed numerous methods of modifying milk; some authorities have recommended simple dilutions of whole milk, while some have felt that babies generally do better if more fat is given, and have, therefore, added cream to the modification or have used dilutions of cream in order to obtain the higher fat content. It is often possible to feed the normal baby on a wide variety of foods, as he has considerable power of adapting himself within certain limits to changes in the composition of his diet. Thus it may be said that no one method of milk modification is the only one that should be used, and others need not be necessarily erroneous. Any method of milk modification is correct for any particular baby if the mixture contains the proper amounts and proportions of the various food elements for him to grow and develop normally. It is desirable, however, to proceed in a rational manner, to change the original cow's milk by design and not haphazard, and to have at one's command methods of milk modification which will allow of varying at will the individual constituents of the milk—fat, sugar, protein, and salts—to meet the needs of various babies with different digestive powers. It is also desirable in any system of milk modification to have a way of

[1] Part of this chapter was published in the Journal of the American Medical Association, March 5, 1921.

expressing what has been done in the exact language of figures in order to make it clear to ourselves, in order to make it intelligible to others, and in order to make our procedures available for purposes of record. There is, therefore, involved in any method of milk modification a certain amount of calculation. Much of the confusion in the minds of practitioners and students that there is in regard to infant feeding has arisen on account of the numerous ways of calculation and methods of modification that have been recommended by different authorities. The important thing to remember is that the particular method of modification which has been used is not the significant fact, but that the content of the resulting mixture as regards the various food elements is the point that must be continually borne in mind, and that many times the identical result may be obtained by two quite different methods of modification. An intelligent practitioner should know his food elements, should have clearly fixed in his mind approximately how much of each one of these elements he desires to feed to the baby, then he may proceed to concoct this combination by means of any method of modification with which he may be familiar. Some men get into the habit of using one particular method, others may use methods which are radically different, but may secure equally good results. Any one who is feeding babies should have at his command several methods, and should use the one which is most adaptable to the particular case with which he happens to be dealing. No matter what methods he uses, he must continually keep the food elements in mind, and must have some method of expressing to himself and to others the amounts of these that he is using.

There are at present three methods of milk modification in general use:

1. The method of whole milk dilution.
2. The method of top milk (cream) dilution.
3. The method of gravity cream and skimmed milk mixtures.

Whole Milk Dilutions.—This is the simplest method of milk modification. It was the first one used in the early days

before the development of modern infant feeding, and in the last ten years has had a revival of popularity. Its chief advantage is its simplicity; any mother, no matter how ignorant she may be, can be easily taught to mix together milk, water, and sugar. It is also easy for the doctor; and most men who are in the habit of using whole milk dilutions pay but little attention to the percentages of the food elements in the mixture; they think rather in terms of ounces of milk and of sugar. It is possible in many cases to feed babies successfully by this method, but it has its limitations, in that it is not at all elastic, and often the ratios which one would like to have between the fat and protein in the mixtures cannot be obtained, owing to the fact that if the milk is diluted one-third or one-half, as the case may be, the fat and the protein will each be diluted in the same proportion. It is very successful with many well babies, but as soon as the baby fails to gain, or begins to do poorly in any way, its disadvantages become apparent, as all that can be done is to either increase or diminish the total concentration of milk or of sugar in the mixture. In whole milk dilutions, therefore, the ratio between the fat and the protein will always be the same, and it is impossible to feed high fats by the use of this method, as the fat content of the milk is so much reduced by dilution. It does not apply so well to very young babies as do the other methods of milk modification, as the usual dilution is so great that the fat percentage of the resulting mixture is much lower than the baby might be able to take with advantage. In normal babies after the eighth or ninth month it is, however, the method of choice, as the dilution for these older babies is so slight that the fat percentage is not much reduced. My own feeling is that young babies as a rule do better on higher fat and lower protein percentages than can be obtained by this method of feeding. There is no question, however, that many babies may be successfully fed in this way. The chief objection to it is that it is not comprehensive nor elastic enough to furnish us with certain combinations of the food elements that we may need, and every practitioner should have in his armamentarium other

methods in addition to this one. Even if whole milk dilutions are used, and no matter how much infant feeding is simplified by their use, it is always well to keep track of the approximate percentage of each food element in the mixture. It is not possible nor desirable to get away from a certain amount of calculation, and a knowledge of the percentage composition of the food acts as a check upon what is being done. No matter what method of milk modification one adopts, in order to have any idea whatsoever about the possibilities of his mixture he must have at least approximate knowledge of its elementary components (fat, sugar, protein). The easiest way to have this knowledge is to think and speak in terms of percentages.

Whole milk dilutions may be used in either one of two ways; the usual procedure being the first:

1. The desired number of ounces of milk and water plus the desired number of tablespoonfuls of sugar are prescribed; then the percentage composition of the mixture is calculated. In using whole milk dilutions one does not usually pick out in advance the percentage composition of the formula, as in many cases he will have picked out a formula which cannot be obtained by these methods. After a certain amount of experience in using this method, one knows without calculation about what the percentage composition of any given dilution of whole milk is, and he expresses his formula in terms of ounces of milk and water and tablespoonfuls of sugar rather than in terms of percentages. In order to proceed rationally, in order to have a clear conception of what he is doing, and especially in order to keep his food elements in mind, he must, however, have an idea of the percentage strength of his mixture. *Every competent feeder of infants has this knowledge, whether he expresses it on paper or not.*

Let us suppose that the baby is being fed on whole milk, 36 ounces; water, 12 ounces, and lactose (milk-sugar), 4 level tablespoonfuls. Then, as whole milk contains fat, 4 per cent.; sugar, 4.5 per cent., and protein, 3.2 per cent., we are giving $\frac{36}{48}$ or $\frac{3}{4}$ whole milk, which equals $\frac{3}{4}$ of $4=3$ per cent. of fat

in the mixture; $\frac{3}{4}$ of 4.5 = 3.3 per cent. of sugar in the mixture, and $\frac{3}{4}$ of 3.2 = 2.4 per cent. of protein in the mixture.

A level tablespoonful of lactose added to a 48-ounce mixture raises the sugar percentage 0.8 per cent. (Table I). Therefore, using 4 level tablespoonfuls of dry lactose, we have added 3.2 per cent. of sugar to the mixture, which, plus the sugar that has already been put in with the milk (3.3 per cent.), gives 5.5 per cent. total sugar, and the baby is getting: fat, 3 per cent.; sugar, 5.5 per cent., and protein, 2.4 per cent.

The same method is used in figuring any whole milk dilution.[1]

Level tablespoonfuls of sugar are best calculated by the use of the sugar table, and ordinarily I believe it is best to use level tablespoonfuls instead of rounded, as more accuracy is obtained in this way. If rounded tablespoonfuls were used the calculation would be a little different. Suppose we had used in the foregoing formula 3 rounded tablespoonfuls of lactose. A rounded tablespoonful of lactose weighs $\frac{1}{2}$ ounce; therefore we have added $1\frac{1}{2}$ ounces of lactose. To transfer this to percentages, $\frac{1.5}{48} \times 100 = 3.1$ per cent. sugar added.

Table I will be found convenient to remember; it is, I think, the easiest way to calculate sugar.

Sucrose (cane-sugar) is somewhat heavier than lactose. Dextrimaltose is somewhat lighter (Table II).

It is not necessary, however, to make special calculations for sucrose or for dextrimaltose; it is usually accurate enough to calculate as if for lactose, and then, if using sucrose, to use a little less than the calculation calls for; if using dextrimaltose, a little more.

2. The second way of using whole milk dilutions is with the aid of a table, and is not quite so practical as the first method. In any whole milk and water dilution, if five-sixteenths of the mixture is milk, that is, 5 ounces of milk in a 16-ounce mixture,

[1] In using this method there is no necessity of being too accurate; for example, supposing we were using 10 ounces of milk and 22 ounces of water in a mixture, it would be perfectly correct to call this one-third milk, or fat, 1.3; sugar, 1.5; protein, 1.1.

and the rest water, the percentages are: fat, 1.25; sugar, 1.40; protein, 1. Similarly, if more milk is added, the percentages are as given in Table III.

TABLE I

CALCULATION OF SUGAR

One level tablespoonful of lactose raises the sugar percentage[1]:

2.40 in a 16-ounce mixture
2.00 in a 20-ounce mixture
1.60 in a 24-ounce mixture
1.20 in a 32-ounce mixture
1.00 in a 40-ounce mixture
0.80 in a 48-ounce mixture

TABLE II

COMPARATIVE WEIGHTS OF SUCROSE, LACTOSE, AND DEXTRIMALTOSE

	Sucrose, gm.	Lactose, gm.	Dextrimaltose, gm.
1 level tablespoonful	15	10	9
1 rounded tablespoonful	25	16	14

Measures

3 level teaspoonfuls = 1 level tablespoonful
2 level tablespoonfuls = 1 large kitchen spoonful

TABLE III

PERCENTAGES OF FAT, SUGAR, AND PROTEIN, ACCORDING TO PROPORTION OF MILK IN MIXTURE

Milk.	Fat.	Sugar.	Protein.
$\frac{6}{16}$	1.50	1.70	1.20
$\frac{7}{16}$	1.75	2.00	1.40
$\frac{8}{16}$	2.00	2.25	1.60
$\frac{9}{16}$	2.21	2.50	1.80
$\frac{10}{16}$	2.50	2.80	2.00
$\frac{11}{16}$	2.75	3.00	2.20
$\frac{12}{16}$	3.00	3.30	2.40

The amount of sugar necessary to add can be determined by referring to the sugar table (Table I). The table of whole milk dilutions is calculated on the basis of sixteenths. Of

[1] These figures are not absolutely accurate, but are near enough for practical purposes, and are adopted for the sake of convenience.

course, if one is dealing with a 32-ounce or a 48-ounce mixture, the fraction $\frac{5}{16}$ or $\frac{6}{16}$, etc., is multiplied through by 2 or 3, as the case may be; that is, $\frac{5}{16}$ is the same as $\frac{10}{32}$ or $\frac{15}{48}$. Proportionate calculations can be made for 24-ounce or 40-ounce formulas; that is, in a 24-ounce mixture the amount of milk required to give the same percentages would be $1\frac{1}{2}$ times what it would be for a 16-ounce mixture, or in a 40-ounce mixture it would be $1\frac{1}{4}$ times what it would be for a 32-ounce mixture. Thus we can accurately figure from this table 16-, 24-, 32-, 40-, and 48-ounce mixtures, which are the most common ones used.

Top Milk (Cream) Dilutions.—The top portions of a quart of milk, after it has been allowed to stand about six hours, contain varying amounts of fat, as in Table IV.

TABLE IV

AMOUNT OF FAT IN TOP MILK[1]

	Per cent. fat.
Top 2 ounces mixed contain	24.0
Top 3 ounces mixed contain	22.5
Top 4 ounces mixed contain	21.4
Top 5 ounces mixed contain	19.2
Top 6 ounces mixed contain	16.8
Top 7 ounces mixed contain	15.0
Top 8 ounces mixed contain	13.3
Top 9 ounces mixed contain	11.5
Top 10 ounces mixed contain	10.5
Top 12 ounces mixed contain	9.0
Top 14 ounces mixed contain	7.8
Top 16 ounces mixed contain	7.0
Top 18 ounces mixed contain	6.3
Top 20 ounces mixed contain	5.8
Top 22 ounces mixed contain	5.4
Top 24 ounces mixed contain	5.0
Top 26 ounces mixed contain	4.7
Top 28 ounces mixed contain	4.5
Top 30 ounces mixed contain	4.3

It is possible by different dilutions of these creams of varying fat percentage to secure mixtures containing more fat than is possible with the use of whole milk dilutions. High fats and

[1] From Morse and Talbot's Infant Feeding.

rather low proteins are obtained by the use of this method of modification, whereas by the use of whole milk dilutions low fats and relatively high proteins are obtained, as we have seen. As may be seen from the table, there are a good many different strengths of cream which may be used; practically it will be found best to confine oneself to the use of the top 10 ounces, top 16 ounces, and top 24 ounces, containing 10, 7, and 5 per cent. of fat respectively. The amounts of sugar and of protein contained in these three different creams vary a little, as shown by Table V; but the variations are so slight that they may be disregarded, and for practical purposes the sugar and protein content of the various creams may be considered to be 4.50 and 3.20 per cent. respectively.

In using these three creams the possible combinations which would be of practical value in infant feeding are as given in Table VI. Sugar may, of course, be added up to any desired percentage, using the same sugar table as for whole milk dilutions.

TABLE V

Composition of 10, 7, and 5 Per Cent. Creams[1]

	Percentages		
	Fat.	Sugar.	Protein.
10 per cent. cream	10.00	4.40	3.25
7 per cent. cream	7.00	4.45	3.40
5 per cent. cream	5.00	4.50	3.50

TABLE VI

Formulæ From 10, 7, and 5 Per Cent. Creams of Practical Value

Combination.	Percentages		
	Fat.	Sugar.	Protein.
10 per cent.:			
Cream, 1 part; water, 2 parts	3.3	1.5	1.1
Cream, 1 part; water, 3 parts	2.5	1.1	0.80
7 per cent.:			
Cream, 1 part; water, 1 part	3.50	2.25	1.60
Cream, 1 part; water, 2 parts	2.50	1.50	1.10
Cream, 1 part; water, 3 parts	1.80	1.10	0.80
5 per cent.:			
Cream, 2 parts; water, 1 part	3.2	3.00	2.2
Cream, 1 part; water, 1 part	2.50	2.25	1.60
Cream, 1 part; water, 2 parts	1.70	1.50	1.10

[1] From Morse and Talbot's Infant Feeding.

This method of milk modification is employed considerably, and when used with intelligence carries with it no objections. It is not at all uncommon, however, to see mixtures containing 5 or 6 per cent. of fat obtained by this method, which is, of course, quite unsuitable for any baby. If cream dilutions are used, the fat content of the original cream and of the resulting mixture must be borne carefully in mind. Many men forget this. It is possible, of course, in using this method to get innumerable formulas by various dilutions of 6, 8, and 12 per cent. creams, or by dilutions of the bottom milk after certain amounts of the cream have been removed; but the introduction of so many different strengths of cream and of milk makes such a complicated array of figures which are so difficult to remember that it is best for practical purposes, if using this method, to confine oneself to dilutions of 10, 7, and 5 per cent. creams, as given above. The use of even these three strengths of cream introduces an unnecessary complication, as any mixture that can be obtained by these methods can likewise be obtained by the gravity cream and skimmed milk method by using only one standard strength of cream in combination with skimmed milk.

Gravity Cream and Skimmed Milk Mixtures.—The method of gravity cream and skimmed milk mixtures is the method of milk modification that is the most adaptable to the needs of various babies. In one respect it is more complicated than the other methods, as instead of using simply dilutions of milk or of cream, when we have but one diluted factor to consider, we have here two diluted factors. The purpose of this method is to furnish a means of obtaining practically any combination of the food elements that we desire. Most of the protein is furnished by the skimmed milk; then enough cream of a known fat content (16 per cent.) is added to supply the required fat percentage. It is inevitable in any such method as this that there should be a certain amount of calculation; we could not speak simply in terms of so much cream, skimmed milk, water, and sugar, and have any idea whatever of what we were giving to the baby. We must speak in terms of percentages always in using this method.

My own feeling is that this is the best method of milk modification for general use. It does not apply to very ignorant patients who have not the intelligence or the desire to go through the procedure involved; for these whole milk dilutions must be used. Most mothers or nurses will be able to handle gravity cream and skimmed milk dilutions without trouble, however, and the amount of calculation involved for the practitioner is not at all difficult or complicated when it has been once mastered. It is a most practical and intelligent way of feeding, and enables the practitioner to change the amounts of protein and of fat in his mixtures much more easily than by any other method. It tends to do away with empiricism, and tends to make those using it think more accurately in terms of the food elements than they would otherwise. Its disadvantage is that there is more calculation involved in it than in the other two methods of milk modification. If it is worth while, if it offers advantages, and I believe it does, the small amount of extra trouble involved should not count against it.

Let us consider for a moment what we mean by gravity cream and skimmed milk. After a quart of milk in the ordinary milk jar has stood about six hours the cream comes to the top, and is separated from the milk by a fairly definite line known as the cream line. All this cream is known as gravity cream. This will usually amount to about 6 ounces. All the cream down to the cream line is then gravity cream, and contains: fat, 16; sugar, 4.5, and protein, 3.2 per cent. What is left behind is the "skimmed milk," which contains: fat, 0; sugar, 4.5, and protein, 3.2 per cent. These figures are not strictly accurate, but the errors in one counterbalance those in the other. "Skimmed milk" actually contains a little fat, but for practical purposes this may be disregarded. The advantages of using "gravity" cream instead of creams obtained in other ways is that it does away with confusion, and we have simply to remember that the cream we are dealing with always contains 16 per cent. of fat instead of trying to remember the fat content of several different layers of cream, as is done by the "top milk" method. The

best method of separating the gravity cream from the skimmed milk is to dip it off with a little dipper devised by Dr. Henry Chapin, of New York, and called, after him, the "Chapin dipper." This can be obtained at any large drug store. Pouring can be used if no dipper is obtainable, but it is not quite so accurate. An important practical point to remember is to tell the mother to remove all the cream on the quart, and to explain to her carefully what gravity cream is. Otherwise she is very likely, supposing the formula calls for 3 or 4 ounces of cream, to take off simply the top 3 or 4 ounces, and use this, in which case she would be using a 20 or 22 per cent. cream, and would be putting more fat in the mixture than was prescribed. All the cream down to the cream line should be removed, put into a bowl, and mixed; then the required number of ounces is taken from this.

Calculation of Formulæ.—There are two ways of calculating gravity cream and skimmed milk mixtures, which may be called the "long" method and the "short" method. The long method employs no short cuts, calculates each ingredient step by step, and is a rather laborious procedure. It is not necessary to use it in actual practice, but it is desirable to know, as he who understands this method of calculation will understand the principles of calculating the percentages of any formula, no matter what its ingredients are, without the use of any tables or equations. Inasmuch as the "short method" is the best to use in actual practice, however, and in order to avoid confusion, I have put the long method in an Appendix at the end of the chapter.

Short Method.—The easiest way of calculating gravity cream and skimmed milk mixtures is by the use of a table of factors, which can be carried in the pocket or notebook on a little card, and which is easily memorized after it has been used a few times. By its use all the necessary calculation can be done in the head. The question of calculation is what has deterred many men from using the gravity cream and skimmed milk method, and it is true that the long way of calculating is rather laborious.

Nor have the various algebraic equations which have been proposed from time to time helped the situation; they have made it more complicated. *The method about to be described is really practical and simple, and the calculation involved is so easy that no one need be daunted by it, no matter how hazy he may be with regard to mathematics.* By its use we are confined to 16-, 20-, 24-, 32-, 40-, and 48-ounce mixtures; but as these are the mixtures ordinarily used, this is not a disadvantage. The basis of the method is that in these mixtures certain constant simple ratios exist between the fat percentage desired and the number of ounces of gravity cream required to get it; also, definite ratios exist between the protein percentage desired and the number of ounces of cream plus skimmed milk required to get it.

Principles of Calculation.—Amount of Cream.—In a 16-ounce mixture the number of ounces of gravity cream required is always the same as the fat percentage desired. In a 32-ounce mixture the number of ounces of gravity cream required is always twice the fat percentage desired; in a 48-ounce mixture, three times. There are similar factors for the other mixtures (20-, 24-, and 40-ounce mixtures—Table VII). This does away with all paper calculations, as the whole thing is so simple that it can be done in the head in a moment.

Amount of Skimmed Milk.—In a 16-ounce mixture the number of ounces of skimmed milk, plus cream required, is always 5 times the percentage of protein desired; in a 32-ounce mixture, 10 times; in a 48-ounce mixture, 15 times. Similar factors exist for the other mixtures (20-ounce, 24-ounce, etc.). The number of ounces of skimmed milk necessary is easily obtained by subtracting the number of ounces of cream obtained in the first calculation from the number of ounces of cream plus skimmed milk obtained in the second calculation.

Amount of Sugar to Add.—Some sugar is, of course, put in with the cream and skimmed milk, as both of these contain sugar. In order to know how much more sugar to add in the form of dry sugar to bring the total up to the desired percentage it is necessary first to know what percentage the cream and

skimmed milk furnished. The percentage of sugar furnished by the cream and skimmed milk is always 1½ times the percentage of protein desired. The extra sugar to be added is figured from the sugar table, showing how much the percentage of sugar is increased in any mixture by adding a level tablespoonful of sugar.

TABLE VII

FACTORS

	Fat factor.[1]	Protein factor.[2]
16-ounce mixture	1.00	5.00
20-ounce mixture	1.25	6.25
24-ounce mixture	1.50	7.5
32-ounce mixture	2.0	10.0
40-ounce mixture	2.50	12.5
48-ounce mixture	3.0	15.0

Sugar Table

One level tablespoonful of lactose raises the sugar percentage:

2.40 per cent. in a 16-ounce mixture
2.00 per cent. in a 20-ounce mixture
1.60 per cent. in a 24-ounce mixture
1.20 per cent. in a 32-ounce mixture
1.00 per cent. in a 40-ounce mixture
0.80 per cent. in a 48-ounce mixture

EXAMPLE

Suppose we wish a 32-ounce mixture containing: fat, 2.5; sugar, 6, and protein, 1 per cent.

To determine:

1. Gravity cream: 2.5 × 2 (fat factor for 32 oz.) = 5 oz. gravity cream.
2. Skimmed milk: 1.00 × 10 (protein factor for 32 oz.) = 10 oz. skimmed milk plus cream. Minus 5 oz. cream = 5 oz. skimmed milk.
3. Sugar:
   (*a*) Sugar furnished by skimmed milk and cream: 1.00 (protein percentage desired) × 1½ = 1.50 per cent. sugar.
   (*b*) Sugar to add as dry lactose: 6.00 — 1.50 = 4.50 per cent. more to be added. One level tablespoonful of dry milk-sugar added to a 32-oz. mixture raises the sugar percentage 1.2 per cent. Therefore add 4 level tablespoonfuls of milk-sugar.

[1] Multiply by percentage of fat desired. This gives ounces of gravity cream to use.

[2] Multiply by percentage of protein desired. This gives ounces of gravity cream plus skimmed milk to use.

This is an accurate and exceedingly simple method once its details are understood, and by its use the gravity cream and skimmed milk method of modification should be robbed of its difficulties and be made practical for general use. If the reader will take the trouble to study it, he will see that this is true.

It seems to me that the best thing for the average practitioner to do is to learn the whole milk and the gravity cream and skimmed milk methods, discarding the method of top milk dilutions. He will then have at his command a wide range of formulæ, and if he desires to feed more fat to his babies than can be obtained by the whole milk method (which is undoubtedly serviceable in many cases), he can turn to gravity cream and skimmed milk mixtures. Any method of calculation seems complex and difficult to understand at first glance; at least it does to me in any text-book of infant feeding I may happen to pick up. *Let me insist that no man can learn a method of calculating milk formulas by simply reading it over once or twice; he must take pencil and paper, sit down and figure a few sample formulæ.* Then he will have no trouble. It is worth while to be able to feed with accuracy. The old days of haphazard feeding have gone by; but there are altogether too many practitioners even now who do not know what they are feeding their babies; to them cream is simply "cream," irrespective of its fat content; many of them have not even a knowledge of the composition of whole milk. The obtaining of approximate accuracy in infant feeding is so easy that it seems a pity it should not be universally adhered to. I say "approximate accuracy," for, of course, it is not possible or necessary to secure absolute accuracy in any milk modification. The ingredients vary too much; and any chain is only as strong as its weakest link. Relative accuracy is what is desired, and in calculating formulæ it is not necessary to pay much attention to insignificant fractions. *The ability to express in numerical terms the approximate amount of each individual food element in the baby's milk mixture seems to me a necessary fundamental of scientific infant feeding.*

Expression in percentages has been usually employed. Expression in grams or in drams would be equally as good if one were accustomed to think in that way. The "percentage method," so called, is really not a method of feeding; it is a method of expression merely, and it does not demand that those who follow it should feed high or low fats, sugars, or proteins; it merely requires that cognizance should be taken of the amounts of these elements that are to be fed. The expression of these amounts in terms of percentages is usually the most convenient notation to adopt.

Calories.—It is often of advantage to know approximately how many calories are contained in the formula. The caloric value of the food is determined not in advance, but after the modification has been made up, merely as a check. This may be calculated in a number of different ways, according to what method of milk modification one is using.

I. The sum of twice the fat percentage given in the food plus the carbohydrate percentage (sugar or starch) plus the protein percentage, multiplied by $1\frac{1}{4}$ times the twenty-four-hour amount of food in ounces gives the total calories for the day. This may be represented by the following equation:

$$(2F + S + P)\ 1\tfrac{1}{4}\ Q^{1} = \text{total calories per twenty-four hours.}$$

Example:

32 oz. of a formula containing

	Fat.	Sugar.	Protein.	
	3.00	7.00	2.00	are being used.

$$\begin{aligned} 2F &= 6.00 \\ S &= 7.00 \\ P &= \underline{2.00}\ 1\tfrac{1}{4}\ \text{(daily quantity in ounces)} = 40 \\ &\ \ 15.00 \times 40 = 600 \text{ calories per day.} \end{aligned}$$

II. In using whole milk dilutions:

1 ounce of whole milk = 20 calories.

1 level tablespoonful of milk-sugar = 40 calories.

1 rounded tablespoonful of milk-sugar = 60 calories.

1 ounce of milk-sugar = 120 calories.

[1] Q represents the total number of ounces of modification taken in twenty-four hours.

The Calculation of Whey Mixtures.—Whey mixtures consist of whey as a basis, to which enough cream and sugar have been added to obtain the desired fat and sugar percentages, the purpose being to obtain a mixture relatively high in whey protein and low in casein. The smaller the amount of cream added, the lower will be the casein percentage. Therefore, if it is desired to obtain whey mixture with a very low casein content, which will still contain a considerable amount of fat, 24 per cent. cream (the top 2 ounces from the quart) may be used instead of the ordinary 16 per cent. (gravity) cream. If 24 per cent. cream is used, calculate as if for 16 per cent. cream, and then use only two-thirds as much of it. For practical purposes it is not necessary to calculate the exact amounts of whey and casein in a whey mixture; we know that the percentage of whey protein in whey is about 0.90 per cent., that this will be reduced slightly by the cream which is added, and that usually from 0.40 to 0.60 per cent. of casein is furnished by the cream which is added to obtain the usual 2 or 3 per cent. of fat. Any closer calculations make the prescribing of whey mixtures unnecessarily complicated without obtaining any additional information that is of practical value. The following is the usual procedure employed: Whey contains fat .00, sugar 4.50, whey protein 0.90. Suppose we wished a 32-ounce whey mixture containing 2 per cent. of fat and 6 per cent. of sugar. How much gravity cream is necessary to give 2 per cent. of fat in a 32-ounce mixture? By referring to the table of fat factors previously used in calculating ordinary modifications we see that in any 32-ounce mixture it is necessary to use twice the number of ounces of 16 per cent. cream as the fat percentage desired. In this case we want 2 per cent. of fat. Therefore use 4 ounces of cream. If 24 per cent. cream were used, two-thirds the amount, or about $2\frac{1}{2}$ ounces, would be used. The rest of the mixture is, of course, made up from whey (28 ounces). We desire 6 per cent. of sugar in the final mixture. How much sugar is already there? Inasmuch as whey and gravity cream are the only ingredients in the mixture, and each contains

4.50 per cent. of sugar, the mixture contains this amount. Therefore we need to add 1.5 per cent. extra sugar or about $1\frac{1}{3}$ level tablespoons (see sugar table).

If it is desired to calculate more acurately the amounts of whey protein and of casein in such a mixture, it can be done as follows: We had originally in our whey 0.90 per cent. of whey protein. But in our mixture we have somewhat reduced this by adding cream, which contains mostly casein, and a small amount of whey. We have a 32-ounce mixture, containing 28 ounces of whey, therefore we have $\frac{28}{32}$ of 0.90 or 0.84 per cent. whey protein. How much casein did we add to the mixture in the gravity cream used? We added 4 ounces of gravity cream which contains 3.20 per cent. of protein to the 32-ounce mixture. Therefore $\frac{4}{32}$ of 3.20 = 0.40 per cent. casein added. Then our final formula is whey $\frac{\text{protein } 0.85}{\text{casein } \ \ 0.40}$. This calculation is not at all necessary, and is a cumbersome complication.

The Calculation of Starch.—The ordinary barley-water decoctions that are used as diluents contain about 1.50 per cent. starch.[1]

Therefore if we desired 0.75 per cent. starch in the mixture, the amount ordinarily used, one-half of the mixture would have to be barley-water. If we did not wish to dilute our formula so much, and still desired 0.75 per cent. starch, we could use a 3 per cent. starch decoction, and use only one-half as much of it.

Summary.—It is always desirable to know approximately the quantities of the various food elements that any milk modification contains. These quantities could be expressed by any numerical notation, but the most convenient way of expressing them is in terms of percentages. There are several methods of milk modification in use, and it is not of great importance which one is used provided the physician gives enough food in total quantity and the proper combination of individual food elements to suit the digestion of the baby that he is dealing with, and that he knows approximately the quantity of each

[1] Two rounded tablespoonfuls of barley flour to the quart of water.

food element in the mixture, in order that he may vary these quantities at will, that he may be able to proceed in a rational manner, and that he may be able to express to others in the exact language of figures what he has done. The modification of milk is the mechanical part of infant feeding, it is not the calculation that is difficult—any inexperienced medical student can quickly learn milk modification and calculation; the part of infant feeding that is difficult, that requires judgment and experience, that often eludes many of us in spite of years of experience with many babies, *is knowing when to feed what.*

APPENDIX

The "Long" Method of Calculation.—Desirable to know in order to understand the principles involved in any modification, no matter what its ingredients are, but not necessary to use in actual practice:

		Per cent.
Desired formula:	Fat,	3.00
	Sugar,	7.00
	Protein,	2.00

Total formula to equal 32 ounces.

		Per cent.
Gravity cream contains:	Fat,	16.00
	Sugar,	4.50
	Protein,	3.20
Skimmed milk contains:	Fat,	0.00
	Sugar,	4.50
	Protein,	3.20

First Step.—The fat in the mixture is furnished entirely by the gravity cream.

How much gravity cream do we need to furnish the desired 3 per cent. of fat in a 32-ounce mixture?

Inasmuch as gravity cream contains 16 per cent. of fat, and we want only 3 per cent. of fat in the mixture,

$\frac{3}{16}$ of 32 ounces = *6-ounce gravity cream.*

Second Step.—The protein in the mixture is furnished partly by the gravity cream and partly by the skimmed milk.

What is the number of ounces of gravity cream plus skimmed milk required to furnish the desired percentage (2) of protein?

Inasmuch as gravity cream and skimmed milk each contain the same amount of protein (3.20 per cent.),

$\frac{2.00}{3.20}$ of 32 ounces = *20 ounces of skimmed milk plus gravity cream.*

The gravity cream needed is, we know by our previous calculation, 6 ounces.

Therefore 20 − 6 = *14 ounces of skimmed milk.*

Third Step.—The sugar in the mixture is to be furnished partly by the gravity cream and skimmed milk used, partly by the addition of dry sugar. How much sugar does the cream and skimmed milk used contribute toward the desired 7 per cent.?

If we had used 32 ounces of gravity cream in our 32-ounce mixture, we would have put in 4.50 per cent. of sugar, as each one of these ingredients contains 4.50 per cent. sugar. But the sum of the ounces of cream and skimmed milk used equals only 20 ounces. Therefore $\frac{20}{32}$ of 4.50 = 2.8 per cent. sugar was furnished by the gravity cream and skimmed milk used.

Fourth Step.—How much dry sugar do we need?

We have already put in 2.8 per cent. and we want 7 per cent.

7.0 — 2.8 = 4.2 per cent. to be added as dry sugar.

$\frac{4.2}{100}$ of 32 ounces = 1.3 ounces of dry sugar.

A rounded tablespoon of milk-sugar = $\frac{1}{2}$ ounce.

Therefore add $2\frac{3}{4}$ rounded tablespoons of milk-sugar.

Fifth Step.—How much water is to be added?

We have used 20 ounces of skimmed milk and gravity cream. We want a 32-ounce mixture.

Therefore 32 − 20 = 12 ounces of water.

Our final formula is

Gravity cream................	6 ounces
Skimmed milk................	14 ounces
Water........................	12 ounces
Milk-sugar....................	$2\frac{3}{4}$ rounded tablespoonfuls

It is sometimes of advantage to figure backward; that is, supposing a mother tells us she has been using so many ounces

each of gravity cream, skimmed milk, water, and milk-sugar, and we wish to know the percentages contained in the mixture. Taking the formula:

Gravity cream............	9 ounces
Skimmed milk............	21 ounces
Water....................	18 ounces
Milk-sugar...............	4 level tablespoonfuls

First Step.—How much fat is there in the mixture?

If 48 ounces of gravity cream had been used, there would be in the mixture 16 per cent. of fat. But only 9 ounces of gravity cream has been used.

Therefore $\frac{9}{48}$ of 16 = *3 per cent. fat.*

Second Step.—How much protein is there in the mixture?

If the sum of the number of ounces of gravity cream and skimmed milk used equaled 48, then there would be 3.20 per cent. of protein in the mixture, as gravity cream and skimmed milk each contain 3.20 per cent. protein.

But only 9 ounces of cream and 21 ounces of skimmed milk were used, equaling 30 ounces.

Therefore $\frac{30}{48}$ of 3.20 = *2 per cent. protein.*

Third Step.—How much sugar was put in with the cream and skimmed milk?

If the sum of the number of ounces of gravity cream and skimmed milk used equaled 48, then there would have been put in 4.50 per cent. sugar, as gravity cream and skimmed milk each contain 4.50 per cent. sugar. But only 9 ounces of cream and 21 ounces of skimmed milk were used, equaling 30 ounces.

Therefore $\frac{30}{48}$ of 4.50 = *2.8 per cent. sugar.*

Fourth Step.—What percentage was added by the 4 level tablespoons of milk-sugar used?

One level tablespoonful of milk-sugar added to a 48-ounce mixture raises the sugar percentage 0.80 per cent. Therefore 3.2 per cent. of dry milk-sugar was added, which plus the 2.8 per cent. already in the milk and cream used = 6 per cent.

total sugar. The formula contains, then, fat, 3 per cent.; sugar, 6 per cent.; protein, 2 per cent.

These principles of calculation apply to any formula, no matter what its ingredients are, and it is possible by their use to calculate the strength of any mixture that is being used without any tables or algebraic equations.

They are, however, so much more complicated than the first method given, that one would not care to use them, and they are included here rather for reference than for actual use.

CHAPTER VIII

SPECIAL PREPARATIONS USED IN INFANT FEEDING

As Dr. Rachford, of Cincinnati, has so wisely said, the various preparations used in infant feeding are the "tools of the trade," and just as an artisan selects one particular tool for a special purpose, so does the physician have at his command a variety of special preparations which he can use with advantage in certain cases. In general, it is well to employ the ordinary milk modifications if possible, but many times for special indications other preparations have to be used.

Fat probably causes more trouble to the baby than any other one of the food elements, but there are few practical ways in which it can be changed to make it more digestible for him.

Homogenization.—If milk is driven by means of a powerful pump through a finely ground agate valve (homogenizing machine) the fat globules are broken up into innumerable smaller ones, and a much more perfect emulsion is obtained. Babies who have difficulty in taking care of fat will sometimes digest milk prepared in this way much better, the probable explanation being that the digestion and absorption of the fat is greatly facilitated by the fineness of the emulsion. Inasmuch as homogenized milk is available only in large centers where there are milk laboratories, this method of feeding is at present not practical.

The Use of Other Fats in Place of Butter Fat.—The fat of cow's milk is not a particularly easily digestible fat for a number of reasons, as we have seen. Therefore if any fats can be found which are more digestible it is not unreasonable to use them

in infant feeding, in combination with cow's milk from which all the fat has been removed.

Olive oil is an easily digestible fat of good food value, and has a definite place in infant feeding. In general, the simpler a fat is chemically, and the lower melting-point it has, the easier it is of digestion and absorption. Olive oil is much more simple chemically than butter fat, its melting-point is low, and the soaps which are formed from it in the infant's intestine are more soluble and easy of absorption than most of the soaps formed from the acids in butter fat. Therefore olive oil should theoretically be a fat easy of digestion and absorption, and in practice this is found to be true. Olive oil may be given in either one of two ways:

(*a*) By simply putting the baby on a fat-free milk modification, and then feeding a sufficient quantity of olive oil by the spoon. A teaspoonful of olive oil weighs about 5 grams and contains about 45 calories. A liter of cow's milk with 4 per cent. of fat contains 40 grams of fat. 'From this an approximate idea may be obtained of how much olive oil to give. This is a practical way of substituting another fat for butter fat, and is sometimes of real value in infant feeding, and in the feeding of older children as well.

(*b*) *Homogenized Olive Oil.*—By this is meant a combination of a fat-free milk mixture with a certain amount of olive oil, which has been run through the homogenizing machine. By this means a very fine and smooth emulsion of olive oil with the milk is made, and the oil appears to be homogeneously mixed with the milk. The virtue of such a preparation as this probably lies partly in the fact that olive oil is an easily digestible fat anyhow, and that the very fine emulsion makes it still more so. This method of feeding was first advocated by Dr. Maynard Ladd, and it undoubtedly produces marvelous results in some cases. Other cases do not do so well. Although it is a real weapon with which to combat troubles of fat digestion in selected cases, it is not practical for general use, as homogenized milk can be obtained only in the large cities. Dr. Ladd tells

me that he has recently had the Walker-Gordon Company put up homogenized oil in a 32 per cent. emulsion with acacia. This is bottled, can be shipped to any distance, and will keep indefinitely. It is added to fat-free milk combinations in exactly the same way that ordinary cream would be added, and mixes perfectly with the milk. This should put the use of homogenized oil on a practical basis.

The Use of Synthetic Fat Mixtures Prepared to Resemble the Fat of Human Milk.—It is theoretically possible to prepare a milk the fat of which shall be chemically very similar to that of human milk, that is, with the same volatile fatty acid content, melting-point, etc. Dr. Gerstenberger, of Cleveland, has been working on this problem for a number of years, and has prepared a milk which he calls "synthetic milk adapted"[1] ("S. M. A."). The fat of this milk is prepared from

	Per cent.
Tallow oil	0 to 10
Cocoanut oil	about 15
Cocoa-butter	about 20
Cod-liver oil	10
Tallow	55 to 45

According to Gerstenberger very satisfactory results have been obtained by the use of this milk. Such experiments as this are of the utmost value theoretically, and undoubtedly in the future will be of practical importance. At the present time the lack of availability of such a preparation puts it outside the limits of practical use for the majority of pediatrists.[2]

Summary.—Other fats, such as homogenized olive oil and a synthetic fat preparation made to resemble the fat of human milk, may in certain difficult feeding cases be substituted for butter fat with good results. Practically speaking, however, in most communities the only way that the fat in an infant's diet can be changed is to substitute olive oil, fed by the spoon.

[1] Amer. Jour. Dis. Chil., vol. 10, p. 249, 1915.

[2] Since this was written "S. M. A." has been put on the market in powdered form by the Laboratory Products Co., Cleveland, Ohio.

Although the other methods of altering the fat in the food are not now practical for general use, their principle is sound and they open up a field of speculation which may some time be very profitable. There is no question that the chemical peculiarity of butter fat is one of the most important stumbling-blocks in infant feeding. It seems not at all unreasonable to expect that in the future there may be a practical method which will be of general use in substituting for butter fat fats of more easy digestibility.

Sugar.—There are four sugars which may be used in infant feeding:

1. Lactose (milk-sugar)
2. Sucrose (cane-sugar) } Disaccharids.
3. Maltose (malt sugar)
4. Dextrose (grape sugar)—Monosaccharid.

Lactose is the sugar most commonly employed, and is the best one to use as a routine. It is rather easily fermentable, and its assimilation limit is not as high as that of maltose. This latter is, however, of little practical importance. The vast majority of healthy babies can be fed satisfactorily with lactose as the sugar, but if there is a tendency to fermentation, it should be omitted, and a maltose-dextrin preparation substituted.

Sucrose.—The advantage of sucrose is its cheapness, otherwise it has no particular advantage over lactose. Lactose is expensive, and the difference in price may mean a good deal to a poor family. If it does, it is best to use cane-sugar instead of lactose. The only disadvantage that it possesses is that on account of its sweet taste it may develop too great a liking for sweets in the baby, and it may be difficult thereafter to get him to take cereal, etc., unless it is sweetened. It has about the same assimilation limit and ease of fermentation as lactose.

Maltose.—By "maltose" we do not mean pure malt sugar. We mean a mixture of dextrins and maltose. Pure maltose is more of a chemical curiosity than anything else; it is very expensive, difficult to prepare, and if it is used is likely to cause diarrhea. The maltose-dextrins preparations are prepared by

the use of barley malt. Barley malt is nothing more or less than grains of barley which have been kept in a warm, wet place until they sprout. These barley grains contain a ferment-diastase which is capable of breaking down starch into sugar. The barley malt is mixed with a certain amount of starch (wheat, potato, or cornstarch usually), and the starch is broken down by the ferment into maltose and dextrins.

Starch plus barley malt
↓
Dextrins
↓
Maltose

The resulting product consists partly of dextrins and partly of maltose. Malt sugar has been used a great deal of late owing to the emphasis that the Finkelstein school has laid upon lactose fermentation. Malt sugar has a higher assimilation limit than milk-sugar, that is, a baby can take more of malt sugar without showing sugar in the urine than he can of lactose. The assimilation limit of lactose and sucrose is about 3.5 gm. per kilogram of body weight, that of maltose, about 7 gm. Although this point has been made a good deal of by those who advocate the routine feeding of maltose, in reality it is not a very important point, as one would practically never feed a normal baby enough sugar of any sort to cause it to appear in the urine. There seems to be no question that maltose is less fermentable than lactose, and this, indeed, is its chief value. If a baby has a tendency toward loose, acid stools, it is always well to substitute a maltose preparation for lactose. It must be remembered, however, that maltose, while it does not ferment quite so readily as lactose, nevertheless does ferment, and that the simple substitution of maltose for lactose is by no means a cure for most sugar troubles. The maltose preparations, particularly those containing large amounts of maltose, are likely to cause spitting up; if they do so, they should be discontinued and sucrose or lactose substituted. The malt sugar preparations contain varying amounts of maltose and

of dextrins, and, in general, those with much maltose and little dextrins are laxative, while those which contain much dextrin and relatively little maltose are somewhat constipating. The liquid maltose preparations are especially laxative, and the addition of a small amount of such a preparation as Maltine Malt Soup to the milk mixture sometimes works wonders for a constipated baby. Also in cases of chronic fat indigestion with dry soapy stools the addition of a maltose-dextrin preparation with a high maltose content often does a great deal of good.

As a summary it may be said that the indications for the use of a maltose-dextrin preparation are as follows:

1. If there is any tendency to sugar fermentation, use a preparation with a high dextrin and relatively low maltose content, as Meade's dextrimaltose.

2. For constipation: Add two or three tablespoonfuls of a liquid maltose preparation to the day's feeding in addition to the other sugar already there. Or substitute one of the dry maltose-dextrin preparations, such as Mellin's Food or Borcherdt's Malt Sugar, for the sugar already there.

3. For chronic fat indigestion with dry, clay-colored, soapy stools use a liquid maltose preparation in combination with lactose and starch.

4. If it is desired to feed an unusually large amount of sugar to a baby, it is well to use a maltose-dextrin preparation, as in this way there is less danger of bringing about sugar fermentation than if lactose were used.

The contraindications for the maltose preparations are these:

1. Spitting up.

2. Special idiosyncrasy to maltose.

In the past few years a good many maltose-dextrin preparations have been put on the market. Some of these are liquids, some solids, some contain large amounts of maltose and small amounts of dextrins, or vice versa; some are useful for one purpose, some for another. Most of them have a certain amount of potassium carbonate added in order to neutralize the excessive acidity of the malt present.

Composition of Malt-sugar Preparations

Meade's Dextrimaltose No. 1

	Per cent.
Maltose	52
Dextrins	41
Sodium chlorid	2

Meade's Dextrimaltose No. 2

	Per cent.
Maltose	53
Dextrins	42

Meade's Dextrimaltose No. 3

	Per cent.
Maltose	52
Dextrins	41
Potassium carbonate	2

Horlick's Food

	Per cent.
Maltose	64
Dextrins	17
Protein	12
Fat	1.4

Horlick's "Diastoid"

	Per cent.
Maltose	73
Dextrins	11

Borcherdt's Malt Soup Extract[1]

	Per cent.
Maltose	55
Dextrins	12
Protein	6
Potassium carbonate	1.1

Borcherdt's Drimalt Soup Extract

	Per cent.
Maltose	71
Dextrins	13
Protein	9

Borcherdt's "Malt Sugar"

	Per cent.
Maltose	87
Dextrins	5

"Maltine" Malt-Soup Extract[1]

	Per cent.
Maltose	62
Dextrins	3

Mellin's Food

	Per cent.
Maltose	58
Dextrins	20
Protein	10
Fat	0.16
Potassium bicarbonate	2.5

"Malt Soup."—Keller's "Malt Soup," which was originally introduced by Liebig in 1865 and later reintroduced and somewhat modified by Keller in 1898, is often of considerable value when it is desirable to offer a low fat percentage in combination with a high carbohydrate content in an easily assimilable form (see Chronic Fat Indigestion). It is often possible to feed to a baby a larger amount of carbohydrate if several different forms of carbohydrate are used, than if only one is employed. The reason for this is that the various carbohydrates are absorbed with different degrees of rapidity, and therefore if we offer a

[1] Liquids of the consistency and appearance of molasses.

mixture containing several carbohydrates, some of which are broken down and absorbed rapidly, some slowly, there is not so much likelihood of a large amount of fermentable carbohydrate being free in the intestine at one time. Malt soup is especially indicated where there is lowered fat tolerance, or in any case when it is desirable to feed a high carbohydrate percentage.

It is usually prepared as follows:

Four tablespoons of liquid malt soup extract are dissolved in 22 ounces of warm water.

Five and a half level tablespoons of wheat flour are rubbed up in a little milk to make a thin paste, then more milk is added up to 11 ounces. The mixture of flour and milk is strained through a fine sieve. Mixture No. 1, containing the malt extract, is then added to mixture No. 2, and the whole boiled in a double boiler for ten minutes. Water is then added to make 33 ounces. The resulting mixture contains four different carbohydrates—lactose, maltose, dextrins, and starch—and has the following percentage composition:

	Per cent.
Fat	1.25
Carbohydrate	12.00
Protein	2.00[1]

There are at present at least two preparations on the market in which the malt extract is in a dry form and is mixed with wheat flour all ready for mixing with milk. Analyses of these are as follows:

Borcherdt's Dry Malt Soup Extract with wheat flour.

	Per cent.
Maltose	46.8
Dextrins	9.4
Starch	31.1
Protein	8.2
Ash	2.2
Moisture	2.3

Mead's Dry Malt Soup Extract with wheat flour.

	Per cent.
Maltose, Dextrins	47
Wheat flour	47
Potassium carbonate	1
Moisture	5

[1] Part of the protein is vegetable protein from the wheat flour.

The same principle—*i. e.*, low fat and high polycarbohydrate feeding—can, of course, be used without making up the malt soup according to the usual formula, and it is often desirable to vary it considerably to fit the needs of the individual baby. Any milk mixture with a low fat content which has malt extract and a cereal diluent added to it and is then boiled is, in reality, a malt soup. The principle of low fat and high polycarbohydrate feeding is a most excellent one, and will be found useful in many cases. It will usually be found best, however, to apply the principle in accordance with the individual baby one is dealing with, rather than to follow any set rule for making the malt soup.

Dextrose.—Whereas the sugars that we have been discussing are disaccharids or comple sugars, dextrose is a monosaccharid or simple sugar. While it is necessary for the disaccharid to be broken down into monosaccharids before they can be absorbed, dextrose is absorbed without further change. This would seem to make dextrose an ideal sugar for feeding where quick absorption is desired. It is very easily fermentable, and on this account has been used only very little in practical infant feeding. Marriott[1] in 1919, however, advocated the use of corn syrup containing dextrose in combination with lactic acid milk, on the grounds that it would probably be absorbed when given in this combination before it could be attacked by the intestinal bacteria and broken down. He used commercial corn syrup, which contains

	Per cent.
Maltose	20
Dextrose	15
Dextrin	32
Cane-sugar	3

This is used by mixing 45 volumes of the syrup with 55 volumes of water, which gives a thin syrup; 100 c.c. of this contains approximately 50 gm. of carbohydrate. This was added to lactic acid milk by Marriott in some cases, so that the total carbohydrate in the mixture was as high as 10 to 15 per cent.

[1] Jour. Amer. Med. Assoc., vol. 13, No. 16, 1919.

It is surprising to see how much carbohydrate can often be taken in this way without fermentation occurring.

This method of feeding is recommended by Marriott especially for severe cases of malnutrition. The chief difficulty in dealing with these babies is that they need more food than the normal baby, and still have a very much diminished digestive power. Any food which is high in caloric value and still not easily fermentable would seem to be an ideal food upon which to feed them. The lactic acid milk and corn syrup mixtures seem to fulfil these indications. It is, in reality, much the same principle as that involved in malt soup, a polycarbohydrate food with which it is possible to enable the baby to absorb and burn large amounts of carbohydrate without much danger of intestinal fermentation. It is often of considerable value in older children with chronic intestinal indigestion (see Chapter XI).

Starch.—It has been shown many times that even newborn babies have the power of digesting starch. Practically speaking, however, starch is not ordinarily included in the diet until the sixth or seventh month, although for special indications it may often be used earlier than this. It is often of advantage to substitute a cereal diluent for water in the milk modification where it is desired to add more carbohydrate to the diet, but not in the form of sugar. From ½ to 1 per cent. of starch is easily tolerated by most babies over four or five months old, and starch being not easily fermentable, may often take the place of an equivalent amount of sugar in the diet if the sugar tolerance is low. A cereal diluent added to the mixture also makes the casein curd more digestible. The most common cereal diluents used are barley-water or oat-water.

Barley- or Oat-water.—Mix 1 rounded tablespoon of Robinson's, Brooks', or Meade's barley flour with 1 pint of water in a double boiler. Boil one-half hour. Add enough water to make up for what has been boiled away, and strain. The resulting gruel contains about 1.50 per cent. of starch. The same directions are followed for oat-water, using oat flour, prepared groats, or oatmeal itself. Oatmeal-water has a slight laxative action.

Barley or Oat Jelly.—In making barley or oat jelly use a well-rounded tablespoon of prepared barley or oat flour to about 8 ounces water. Cook in a double boiler for three-quarters of an hour. Salt and strain. The resulting product should be just too thick to run, but not so thick as a cereal would be when used in the adult dietary. If oat jelly is made from oatmeal instead of oat flour it should be cooked three hours, and strained through a colander to get rid of all coarse particles.

Protein.—*The Curdling of Milk by Rennin.*—The milk-curdling enzymes of the gastric juice split the casein through a process of hydrolytic cleavage into soluble paracasein and a peptone-like body. The soluble paracasein then forms a combination with the soluble calcium salts of the milk and an insoluble curd of paracasein results. Practically all the fat in the milk is entangled in the meshes of the casein curd and precipitated also. The curd consists then of all the casein, the fat, and most of the calcium salts. The whey, or fluid that is left contains the lactose, lactalbumin, and the rest of the salts (mostly sodium and potassium salts). Inasmuch as the curd formed from cow's milk in the infant's stomach is of tough, leathery consistency, and is difficult of digestion, it is often desirable to do something to the milk mixture so that a soft and flocculent curd will result, more resembling that of human milk. This may be brought about in a number of ways:

1. Simple dilution of the milk mixture by decreasing the concentration of the casein and calcium tends to make a softer curd.

2. Boiling the milk makes a softer curd, probably due to the fact that a considerable amount of the calcium salts are precipitated by boiling. In order to bring this about the milk should be boiled ten minutes if in a double boiler, and three to five minutes if boiling vigorously over the free flame.

3. By adding a cereal diluent, such as barley- or oat-water. In order to secure the best results the mixture should contain about 0.75 per cent. of starch. This method is not so efficient

as some of the others, but may be used in combination with them.

4. By adding an alkali, which hinders curd formation, as rennin does not work in an alkaline medium. Three alkalies are in ordinary use:

Lime-water.—If lime-water is used it must be used in amounts equal to at least 25 per cent. of the milk or milk and cream in the mixture. Any less amount does no good. If lime-water in amounts equal to 50 per cent. of the milk or milk and cream is added, gastric digestion is almost totally inhibited.

Sodium Citrate.—In practice this is easier to use than lime-water, as it is less bulky, and is probably just as efficient. Either 1 or 2 grains of sodium citrate is used to each ounce of milk or milk and cream in the mixture. What I ordinarily do is to give a prescription containing about 20 grains of sodium citrate to the teaspoonful of water, and then direct that either 1, 2, or 3 teaspoonfuls, as the case may be, be added to the day's milk supply.

℞. Sodium citrate................ ℥ij;
Water.....................ad. ℥viij.—M.
S.—Add 2 teaspoonfuls to the day's feeding.

This would give 40 grains of sodium citrate, and would be suitable for a modification containing from 30 to 40 ounces of milk.

Soda Bicarbonate.—This is used in the same strength as sodium citrate, but has the disadvantage that it may upset the stomach. It also causes an unpleasant taste in the milk.

5. *Peptonization.*—By predigestion of the casein of the milk before the baby takes it curd formation can be prevented. This is a rather laborious process, however, and the other ways of making a soft curd are so much more simple that it is not much used now. Peptonized milk may sometimes be valuable for very weak babies or for rectal feeding, however. The best way to peptonize milk is as follows: Dissolve the contents of a "peptonizing tube" in 8 tablespoonfuls of warm water. Add a

tablespoonful of this solution to the feeding when it is removed from the ice-chest, and warm it by immersing the bottle in hot water for about fifteen minutes, in the same way as when an ordinary feeding is given. The feeding should then be given immediately.

6. By inoculating the milk with lactic acid bacilli the protein is precipitated in fine flakes as "lactate of casein," and does not coagulate again in the stomach (see Lactic Acid Milk).

7. *Whey Mixtures.*—In the early days of scientific infant feeding, when the casein of cow's milk was supposed to be extremely difficult of digestion, whey mixtures, that is, mixtures made with whey and gravity cream, in order to get rid of the casein, were used a great deal. At the present time we believe that casein, when given in suitable amounts, and particularly if the milk is boiled, causes very little trouble. Whey mixtures are, therefore, but little used. They may be useful occasionally for newborn, premature, or very weak babies, or for babies who vomit. They should never be used if there is a tendency to diarrhea.

Preparation of Whey.—To 24 ounces of warm (100° F.) skimmed milk add 2 teaspoonfuls of essence of pepsin and stir. Let it stand until it has jellied, break up the curd with a knife, and strain through cheese-cloth. If the whey is to be used in combination with cream it should be heated to 160° F. in order to destroy the ferment, as if this is not done the casein of the cream will be curdled by it. Whey contains:

	Per cent.
Fat	0.00
Lactose	4.50–5.00
Whey protein	0.90
Salts	0.80–0.90

Lactic Acid Milk.—By lactic acid milk is meant a milk "soured" with bacilli of the lactic acid group. It may be produced naturally, as in butter making, or artificially, by adding a culture of lactic acid bacilli to the milk and allowing it to incubate.

Lactic acid milk has been used to a certain extent for a long time in infant feeding, its use probably originating in Holland, but it is only in the last few years that it has been employed extensively. The lactic acid bacillus when introduced into milk multiples very rapidly, and produces lactic acid fermentation of the milk-sugar, with the formation of a considerable amount of lactic acid. When the acidity has reached a certain degree the casein of the milk is precipitated in fine flakes. Lactic acid milk is usually made from fat-free milk, or from milk containing very small amounts of fat, and during the process of fermentation the sugar content is, of course, reduced considerably. It is then a food low in fat, low in sugar, and containing a varying amount of lactic acid, together with enormous numbers of lactic acid organisms. It is also *relatively* high in protein, in an easily assimilable form, for inasmuch as the casein has been once precipitated it does not coagulate again in the stomach. Commercial buttermilk varies somewhat in composition, but is usually about as follows:

	Per cent.
Fat	0.50–1
Sugar	3.75–4
Protein	3.50

The artificially made preparations have approximately the same composition. The use of lactic acid milk is founded upon its ability to reduce intestinal fermentation and putrefaction owing to the flooding of the intestine with lactic acid bacilli, which are antagonistic to and suppress the growth of the harmful organisms present. Also the fact that it contains a low fat and sugar and a relatively high protein is of considerable importance when it is used as a corrective diet in cases of sugar fermentation. It has a great deal of use in infant feeding, particularly as a diet in the diarrheal diseases of infancy, and also in cases of chronic intestinal indigestion in older children.

It is best, if possible, to use an artificially made preparation rather than the natural buttermilk, as the age and purity of the latter are often doubtful, and it may be infected with

undesirable organisms in addition to the desirable lactic acid bacillus.

Lactic acid milk may be easily prepared in the home from any one of the liquid cultures that are now on the market. In the late afternoon the contents of a culture-tube is mixed with the milk, and allowed to stand over night, preferably in a warm place. The next morning the lactic acid milk is ready. If the fermentation has not been carried too far, there will be no separation of the curd and whey; if it has been carried too far, it is excessively sour, bubbly, and the curd and whey become separated. If this occurs, less of the culture should be used and the milk allowed to stand in a somewhat cooler place.

If desired, up to 2 per cent. fat may be used with lactic acid milk, but it is not well to attempt to use more than this, as sometimes with even this amount the resulting product is too thick and slimy.

Babies under six or seven months of age usually take lactic acid milk preparations as readily as any other milk, but older babies, particularly those over a year old, are likely to refuse it for the first few feedings. It is rare indeed, however, to find a baby who cannot be made to take it eventually. It should be offered at regular intervals, every three or four hours, as the case may be, and after several refusals the baby finally gets so hungry that he is glad to take anything he can get. If after forty-eight hours of persistent forcing he still refuses to take it, it is usually advisable to give up and use some other method of feeding.

Protein Milk ("Eiweissmilch"; Albumin Milk).—The best term for this preparation is "protein milk." The words "eiweiss" and "albumin" are misnomers, as the getting rid of the whey protein (albumin), with its salts, is one of the objects of the milk. The purpose of protein milk is to supply a food low in sugar and high in protein (casein) in an easily assimilable form. It was devised by Finkelstein in 1910, and since then has been used by thousands of physicians all over the world. It is of especial value in cases of sugar fermentation, and is one of the best weapons we possess in dealing with this type of case. It is

not a universal food for all types of feeding cases, it is not a food to be fed to normal babies, it is not a food to feed to any baby over a long period of time. Its value is due to the fact that it alkalinizes the intestine very quickly, and by the withdrawal of fermentable carbohydrate and the substitution of a relatively large amount of casein in an easily digestible form, plus calcium, conditions are created which favor the production of pasty or formed soapy stools.

Protein milk is prepared as follows:

To 1 quart of whole milk in a saucepan add 2 teaspoons of Fairchild's Essence of Pepsin. Let it stand at blood heat for about half an hour, then break up the curd gently with a knife, transfer the whole to a cheese-cloth bag, and allow the whey to strain off (usually let it strain one hour). Then rub the curd through a fine wire sieve with a potato-masher into a pint of fat-free lactic acid milk or buttermilk, and make the total mixture up to 1 quart by the addition of water. It is essential that the curd be in a very finely divided form, and in order to attain this it is usually necessary to rub it through the sieve several times.

The final product contains: fat, 2.5 per cent.; sugar, 1.5 per cent.; protein, 3 per cent.; salts, 0.50 per cent. Dextrimaltose should be added up to about 3 per cent., as it may be dangerous to feed *too* low a sugar.

The protein furnished to the mixture by the buttermilk is in a finely divided, precipitated form, as is also that furnished by the rubbed curd, so that it cannot be curdled again in the stomach, and therefore offers the possibility of feeding a large amount of casein in an easily digestible form. This preparation should be warmed very slowly and slightly before being given to the baby, as, if it is heated too hot, clumping of the curd and separation of the whey of the buttermilk will result.

While it is true that protein milk is of very great usefulness, it is rather difficult of prepartion. It *can* be made satisfactorily by intelligent mothers, but there is absolutely no use in trying to employ it in the ordinary out-patient type of case.

The principle of low sugar and high casein for certain cases is a very sound one, and every physician who has babies in his practice should have at his command some method of putting together such a mixture, but the difficulty of preparation deters many men from using this most valuable principle. Let us consider some of the other and more simple ways in which a low sugar and high casein milk of the same general character as protein milk may be obtained.

1. In any city where there is a milk laboratory it is best to have one's high protein milk made at the laboratory. This has the additional advantage that it is not necessary to use the same stock formula for each case, and more individualization is possible. In the laboratory protein milk is made from cream, precipitated casein, and water, the whole then being run through the homogenizing machine in order to secure a smooth mixture. The directions to the laboratory would be given as follows: Fat, 2 to 2.50 per cent.; sugar up to 3 per cent.; precipitated casein up to from 2 to 3.5 per cent., depending upon the age of the baby. In such a mixture as this we would not get the value of the lactic acid bacilli that are in the buttermilk of the original preparation, but if this is desired it is easy enough to have the whole inoculated with the desired organism. The sugar is very low (unless sugar is added), the only sugar present being that which comes from the small amount of cream used to get the desired percentage of fat, and if a heavy cream is used, this is almost negligible. Suppose we wished 2 per cent. of fat in a 32-ounce mixture, and a 32 per cent. cream were used. Only 2 ounces of cream would be required, and this would furnish only about 0.30 per cent. of sugar to the mixture. It is, however, not necessary to get the sugar as low as this, and it is even dangerous, so it is usually best to make up these mixtures with an ordinary gravity cream, and to add dextrimaltose up to about 3 per cent. This is by far the most satisfactory way of using the high casein and low sugar principle if one lives in a big city where there is a milk laboratory. Naturally, it is not available for those living in the country or in smaller cities or towns.

2. *Dried Protein Milk.*—There are two preparations of dried protein milk on the market which when mixed with water give about the same percentage composition as the original Finkelstein preparation. One of these is put up by Louis Hoos, of Chicago, the other by the Canadian Milk Products Co., of Toronto. Although I cannot vouch for the value of these preparations from personal experience, having never had occasion to use them, there seems no reason why as good results could not be obtained with them as with the home-made protein milk, and they should, on account of their ease of preparation in the home (simply mixing with water), be a practical and valuable way of applying the low sugar and high protein principle.

Dried Casein Plus Whole Milk or Buttermilk and Water.—For general use in smaller towns and cities, and with patients who would not have intelligence to carry out any complicated procedure, the addition of dried powdered casein to dilutions of whole milk, skimmed milk, or buttermilk offers a very easy and satisfactory practical way of using the high protein and low sugar principle. In the summer of 1915 I fed between 40 and 50 cases of fermentative diarrhea in this way, and secured excellent results, fully as good, I believe, as could have been secured by the use of any other high protein milk. The preparation used was "Larosan." It is a calcium casein preparation, and is made from dried pure casein to which 2.5 per cent. of calcium oxid has been added. The powder is semisoluble, and can be mixed with gravity cream mixtures or with whole or skimmed milk mixtures, in any proportion desired. The usual method of mixing it is as follows:

Mix one small $\frac{2}{3}$-ounce package in 6 ounces of cold milk, and add this to 10 ounces of whole milk which is at the boiling temperature. Boil five minutes, with constant stirring; this should make a thin and fairly smooth gruel. To this gruel add 1 pint of water. The resulting mixture contains: Fat, 2 per cent.; sugar, 2.20 per cent.; protein, 3.40 per cent.

It is, of course, not necessary to use this preparation in accordance with these directions, and this is one of its chief

advantages, that one can add as much or as little of it as necessary to any sort of milk mixture to secure any percentage of protein desired. If $\frac{1}{3}$-ounce (one-half package of Larosan) is added to a 32-ounce milk mixture approximately 1 per cent. of protein is added. The same amount added to a 48-ounce mixture adds 0.75 per cent. protein. One-quarter of a package ($\frac{1}{6}$ ounce) added to an 8-ounce mixture adds 2 per cent. protein.

Two other dried casein preparations that have recently been put on the market are "Casec" and "Aprotein." The former is a calcium caseinate, the latter a sodium caseinate.[1]

Dry Milk Powders.—In the last few years dried milk feeding has had many advocates. The two brands of dried milk that have been used most extensively are the "Dryco Brand" and "Klim."

The "Dryco Brand" contains:

	Per cent.
Fat	12
Lactose	44
Protein	34
Salts	7

"Klim" dried milk is prepared in two forms, the "skimmed" and the "whole.":

"Skimmed" dried milk.	Per cent.	"Whole" dried milk.	Per cent.
Fat	1.35	Fat	28
Lactose	50.00	Sugar	38
Protein	38.00	Protein	26
Salts	0.00	Salts	5

Dried milk undoubtedly has a definite place in infant feeding. It has come to stay, and while I by no means agree with those who would use it in the majority of their difficult feeding cases, there is no question that it sometimes works remarkably well. It contains (Dryco) a low fat, relatively low sugar, and a high protein in an easily assimilable form, which is not coagulated in the stomach. It sometimes works very well in cases of fat intolerance, of sugar fermentation, and also with vomiting

[1] Since this was written "Protolac" has also appeared.

babies. It is also naturally of great value for traveling, or in any locality where clean breast milk cannot be obtained. It should be a godsend to the South in the summer.

One level tablespoonful of Dryco to 1 ounce of water gives a mixture containing fat, 1.50 per cent.; sugar, 5.50 per cent.; protein, 4 per cent.

It is most often used in this proportion, but for babies with weak digestive powers, especially in starting, it is best to begin about half-strength, and then gradually work up. It contains 16 calories to the level tablespoon, and in order to supply a baby with 50 calories per pound per day it is necessary to use 3 level tablespoons per day for each pound of body weight (Dennett[1]). If it is desired to increase the carbohydrate content, milk-sugar or dextrimaltose may be added, or it may be advantageously combined with barley-water if it is desired to feed starch. If more fat is wanted, "Klim" can be used instead of "Dryco," as when whole "Klim" dried milk is mixed with water in the proportion of 1 level tablespoon to 2 ounces of water, the formula is almost exactly that of whole cow's milk—3.5 per cent. fat; 4.7 per cent. sugar, and 3.3 per cent. protein, with a caloric value of 20 to the ounce (Root[2]). Babies that are fed on dried milk are very likely to have a strongly ammoniacal urine. If this occurs, it can usually be done away with by adding carbohydrates to the mixture.

Goat's Milk.—There is probably no special advantage of goat's milk over cow's milk, although this has been claimed by some writers. Goats are practically immune to tuberculosis, and I remember a woman who bought a goat simply because she was afraid her baby *might* develop it. The chief use that goat's milk has is as a food for babies who have an anaphylactic idiosyncrasy to cow's milk. For such cases it is a godsend!

Usually no cream rises on goat's milk, probably due to the small size of the fat globules. It has been found by Schultz and Chandler that 91 per cent. of the fat globules of goat's milk are

[1] New York State Jour. Med., July, 1918.
[2] Charlotte Med. Jour., May, 1920.

under 4 microns in diameter, and over half of these are under 2 microns. In cow's milk 90 per cent. of the globules are over 4 microns. The fat globules of goat's milk possess, therefore, a much greater surface are than those of cow's milk, and thus offer a larger surface for the action of the digestive juices.

A goat will usually produce from 12 ounces to 3 quarts of milk a day, and its average composition, which is not much different from cow's milk, is as follows:

	Per cent.
Fat	3.8
Sugar	4.50
Protein	3.10
Salts	0.85

The casein precipitates in the form of a tough, hard curd. It differs from cow's milk, in that it is of an almost pure white color. It is not always easy to get a goat, or to board him after he is obtained, and for this reason a preparation of evaporated goat's milk[1] is often of considerable service. It looks very much like ordinary evaporated cow's milk, and has the following composition:

	Per cent.
Fat	8.50
Protein	7.30
Lactose	9.00
Ash	1.60

One-third of the evaporated milk and two-thirds water gives:

	Per cent.
Fat	2.60
Lactose	3.00
Protein	2.40
Ash	0.50

One-quarter of the milk and three-quarters water gives:

	Per cent.
Fat	2.10
Lactose	2.20
Protein	1.80

[1] Prepared by the Widemann Goat Milk Laboratory, San Francisco.

As can be seen from the diluted formulæ, the sugar is low, and therefore it is well when using this preparation to add sufficient carbohydrate in some form to make up for the deficit.

Beef juice is of value sometimes for babies over eight or nine months of age. It has small caloric value, but contains about 6 per cent. of protein, and a not inconsiderable amount of iron. Its chief purpose is to furnish iron at the time when the baby needs more iron than is contained in milk alone (eight to nine months). Not more than 2 ounces a day should be given, and it is best to begin with only a teaspoonful or two until the baby becomes accustomed to it. Bread-crumbs or rice of powdered zwiebach may be added to the beef juice, although most babies take it better when given plain. It is best made in the following way:

Lightly broil $\frac{1}{2}$ pound of lean beef from the top of the round. Then squeeze as much juice as possible out of it in a meat press (obtainable at most hardware stores), salt, and serve. A half-pound of beef usually furnishes about $1\frac{1}{2}$ ounces of beef juice.

CONDENSED MILK AND THE PROPRIETARY FOODS

Condensed milk has been used extensively in infant feeding, but is now being gradually replaced by the dried milks. In hot climates, or in any place where fresh cow's milk was not available, the use of condensed milk was necessary and advantageous, but at the present time, when we have good dried milk preparations, it should be replaced by them, as they meet the nutritive requirements of the infant much more satisfactorily than does condensed milk. Condensed milk has also been used a good deal in difficult feeding cases, and often recommended by authorities on infant feeding, but personally I have had occasion to use it only very seldom. It cannot contain anything that ordinary milk modifications cannot contain, it is a very poorly balanced food, and its chief virtue is its comparative freedom from bacteria. It is true that some babies with indigestion begin to do well as soon as they are put on condensed milk, but

this is probably due more to the weakness of the food than to any particular virtue contained in it.

Condensed milk consists of cow's milk which has been concentrated by evaporation to a small bulk and to which a large amount of cane-sugar is added. There are many brands on the market the composition of which varies but little. The following figures represent the average composition of twenty well-known brands:

	Per cent.
Fat	8 –10
Protein	7 – 9
Milk-sugar	11 –13
Cane-sugar	38 –45
Ash	1.60– 2
Water	20 –28

It will thus be seen that condensed milk is a food very low in fat, protein, and ash, and very high in carbohydrates. This unbalanced composition is its chief defect, as, if it is diluted to a point which furnishes a reasonable amount of carbohydrates, the protein and salts are diluted so much that the baby is not furnished enough of these building materials which are so important for proper growth. If it is diluted in such a way that the salt and protein percentages are sufficient, the sugar is too high. The following table shows the percentages obtained by various dilutions of condensed milk:

	Condensed milk.	Water.	Fat. Per cent.	Sugar. Per cent	Protein. Per cent.
I	1 part	2 parts	3.00	18	2.00
II	1 "	4 "	1.80	11	1.60
III	1 "	6 "	1.00	6	0.90

It may be of value to carry certain feeding cases (especially those who vomit) along until they can be gradually accustomed to a more suitable food, but it is not a food upon which to feed *any* baby over any length of time, and although we see occasionally a condensed milk baby who has done well, such an instance is the exception rather than the rule. In general, babies who have been fed condensed milk over a long period of time may be divided into three groups:

1. A baby who is of normal weight for his age or grossly overweight. He is round and fat and seems well. On closer examination, however, it is seen that he is pale and his tissues are not firm and solid as they should be. He lacks muscle tissue and has in its place fat and water. A large part of the gain in weight of condensed milk babies is due to water retention, caused by the high carbohydrate feeding, as when large amounts of sugars are fed over a long period of time, large amounts of glycogen are stored in the liver and muscles, and the chemistry of glycogen deposition is such that for each molecule of glycogen formed 2 molecules of water are retained. These babies gain weight quickly, of course; they lose it as quickly, especially during any acute infection, which, as a rule, they bear poorly. Babies of this type have been supplied enough or more than enough calories, but the food has not been well balanced.

2. A much emaciated baby, usually with rickets, if he is over six or seven months of age. This type of baby has been fed on a weak dilution of condensed milk over a long period of time. His caloric intake has not been sufficient, therefore he presents the picture of starvation. He has had just enough to keep body and soul together, but not much more.

3. A baby who is neither very thin nor very fat, but who is *small* for his age. He is delicate looking, rather pale and flabby; his hands and feet and bones are small; he may or may not have a moderate degree of rickets. This is perhaps the most common type of condensed milk baby.

Evaporated milk is somewhat different from condensed milk; it consists of whole cow's milk which has been evaporated to the consistency of thin cream and to which no sugar has been added. It does not keep in the can as does condensed milk (on account of its high sugar content), and a much greater quantity of it is necessary to prepare a formula; therefore it has not been used nearly so much as condensed milk. The composition of most of the evaporated milks is fat 9 per cent., sugar 10 per cent., protein 7 per cent.

One part of evaporated milk to 3 of water gives: Fat, 2.25

per cent.; sugar, 2.5 per cent.; protein, 1.7 per cent. A 1:4 dilution gives: Fat, 1.8 per cent.; sugar, 2 per cent.; protein, 1.4 per cent.

It is necessary, in using evaporated milk, to add sugar, as the original sugar in the milk is reduced so much by dilution.

Evaporated milk does not carry with it the same objections that were pointed out for condensed milk, but it has been used comparatively little in infant feeding, probably on account of the reasons given above.

The Proprietary Foods.—During the early days in the development of modern infant feeding, when everyone was striving to produce a food which should be the equal of human milk, when more attention was paid to the food than to the baby himself, and it was thought that it might be possible to produce a universal food upon which all babies could thrive, a great many proprietary infant foods sprang into being, and were extensively used. As interest in infant feeding has increased, and as practitioners have begun to learn more about the modification of milk, the use of the proprietary foods has correspondingly decreased. There is nothing in any proprietary food which cannot be obtained in any ordinary milk mixture prepared with the ordinary materials used (various sugars, starches, dextrins, creams, etc.), and it is a great deal better for the practitioner to prescribe his own mixture than to use blindly one which is furnished him in a can. There is nothing fraudulent in their preparation, and, in general, their composition corresponds closely to the analyses given on the package. The chief objection to them is that their claims are exaggerated, that their use tends to develop slipshod methods of feeding, and that most of them do not contain the food elements in suitable ratio for the proper nutrition of the baby. They are still used by the laity to a considerable extent, and all of us have occasionally seen strong, healthy babies raised in this way, but we have seen far more who have not done well after having been shifted from one proprietary food to another.

Some of the proprietary foods consist entirely of starch,

TABLE I

Food.	Fat.	Soluble carbo-hydrate sugar.	Starch.	Protein.	Ash.
A. D. S. Malted Milk	6.75	66.97	None	14.06	3.08
Allenbury's Milk Food No. 1	13.80	62.80	None	9.88	3.98
Allenbury's Milk Food No. 2	14.20	66.40	None	9.75	3.70
Allenbury's Milk Food No. 3	0.78	17.54	60.92	9.38	1.18
Benger's Food	0.83	9.69	57.66	10.75	1.00
Borden's Malted Milk	7.15	65.30	None	15.38	3.45
Carnrick's Lacto-Preparata	1.60	74.80	None	13.63	3.38
Carnrick's Soluble Food	1.05	53.45	25.99	12.44	1.30
Cereal Milk	3.55	71.95	1.74	11.00	2.38
Eskay's Albuminized Food	1.28	49.19	31.95	7.75	1.58
Horlick's Malted Milk	8.10	66.04	None	15.00	4.00
Imperial Granum	0.50	2.00	72.79	13.88	0.50
Just Food	0.03	90.30	3.32	0.63	0.30
Lacnut	31.30	36.08	2.31	22.19	2.10
Lactated Food	0.55	29.87	47.93	8.81	0.88
Meadow Brand Malted Milk	5.20	68.09	None	14.50	3.28
Mellazea	2.20	1.62	74.36	5.75	0.60
Mellin's Food	1.80[1]	75.27	None	11.31	4.45
Nestle's Food	5.70	55.48	20.25	11.94	1.45
Peptogenic Milk Powder	0.03	90.89	None	0.19	1.43
Ridge's Food	0.33	3.12	70.93	10.31	0.75
Wampole's Milk Food	5.25	65.14	None	9.19	4.83
Dennos Food[2]	1.17	16.64	57.0	11.10	0.79
Laibose[2]	15.83	54.05	None	19.8	5.30
Mammala[2]	12.12	55.34	None	24.35	4.93
Kindolac[2]	12.93	60.78	None	19.9	4.39
Trumilk[2]	28.73	35.20	None	26.52	5.47

dextrins, and malt sugar, and are intended to be mixed with fresh milk; some contain these substances in combination with dried milk, and are advertised as complete foods; some contain sugar or starches in combination with digestive ferments. If better results in infant feeding could be obtained by the use of proprietary foods than in any other way we should all use them

[1] Is 0.16 per cent. according to other analyses.

[2] Analyses furnished by Mellin's Food Co.

TABLE II

Percentage Composition of Feeding Mixtures, Prepared According to Directions, for Infants Three Months Old

Food.	Fat.	Carbo-hydrate.	Protein.	Ash.
A. D. S. Malted Milk	0.81	8.46	1.69	0.34
Allenbury's Milk Food No. 1	2.17	10.61	1.56	0.63
Allenbury's Milk Food No. 2	2.24	10.73	1.53	0.58
Benger's Food	1.75	4.14	2.10	0.36
Borden's Malted Milk	0.88	8.44	1.88	0.42
Carnrick's Lacto-preparata	0.07	3.55	0.62	0.15
Carnrick's Soluble Food	0.10	8.00	1.19	0.13
Cereal Milk	0.49	10.69	1.51	0.33
Eskay's Albuminized Food	1.77	4.77	2.16	0.40
Horlick's Malted Milk	1.08	9.42	1.99	0.53
Imperial Granum	1.78	3.58	2.10	0.35
Just Food	2.47	6.65	2.63	0.49
Lactated Food	1.86	3.73	2.11	0.38
Meadow Malted Milk	0.66	9.34	1.83	0.42
Mellazea	3.40	7.00	2.05	0.32
Mellin's Food	1.93	5.55	2.42	0.38
Nestle's Food	0.36	4.84	0.75	0.09
Peptogenic Milk Powder	2.04	5.01	1.66	0.34
Ridge's Food	1.75	4.06	2.09	0.36
Wampole's Milk Food	1.02	15.30	1.78	0.93

exclusively. Such is not the case. Table I, taken from Part V of the annual report for 1915 of the Connecticut Agricultural Experiment Station, shows the analyses of most of the proprietary foods. Table II, taken from the same source, shows the composition of the feeding mixtures prepared from certain of these foods, according to the directions furnished, for infants three months old.

CHAPTER IX

THE ARTIFICIAL FEEDING OF THE NORMAL INFANT

Normal babies may thrive on foods of widely different compositions, as they have to a considerable extent the power of adapting themselves to varying diets. So it may be said that there is no *one* and only correct way to feed a baby; any milk modification upon which he will thrive is a satisfactory feeding for him. The type of food, however, which suits *most* babies is naturally the best one for general use. Although it is undoubtedly true that individualization and the fitting of the food to the infant are extremely important points to bear in mind, it is also true that most normal babies do well when fed by very much the same plan of feeding. Although we do not try nowadays to imitate breast milk, it is not unreasonable to suppose that babies should do well on a food of the same general character as breast milk, that is, relatively high in fat and sugar, and low in protein and salts. A food of this nature can best be obtained by the use of gravity cream and skimmed milk mixtures. There has been a great deal of discussion among pediatrists as to whether babies do better on high fats and low proteins or low fats and high proteins. My own feeling is that they do better on the former, and I therefore use this method of feeding more than any other, although not exclusively. High fat is usually well borne if the protein is kept low; high fat plus high protein or high sugar plus high protein is not tolerated. As a matter of fact, there is no need for a baby to take a large amount of protein; we know that breast milk contains only a little over 1 per cent., and still, with an adequate amount of fat and sugar to serve as fuel, this enables the baby to keep in nitrogenous equilibrium, and to retain a considerable amount of nitrogen. Normal bottle-fed babies, likewise, do very well on a relatively low protein food provided enough fat and sugar is supplied for

the fuel needs of the body, so that little or none of the protein has to be used for this purpose.

In using a high fat, cream is essential, and it is, therefore, always necessary to speak and think in terms of percentages of the food elements in employing this method. With several ingredients in the mixture, such as cream, skimmed milk, and sugar, we are hopelessly confused unless we adhere strictly to the percentage method of expression. Note that I say "expression" and not "system," for percentage feeding is not a system, it is a method of expression merely, which becomes necessary if one is to have an adequate idea of what he is doing, particularly if he uses cream or cream and skimmed milk mixtures. Expression in percentages is intended to serve merely as a general guide, and it is by no means necessary to make the very slight changes in percentage or to strive for the meticulous accuracy that was insisted upon by the early advocates of percentage feeding. Various percentages, such as 1, 1.50, or 2, represent merely different gradations of concentration of a food element in a formula, and it is not supposed that a chemical analysis would show the exact percentages called for. This is no disadvantage, however, as what is desired is not absolute but relative accuracy, in order to express approximately the concentration of the food elements, and to indicate how much we have raised or lowered the amount of any element in a mixture. If these suggestions are borne in mind the percentage method of expression will be found to be a real help.

The composition of the food, that is, the relationship of the fat, sugar, and protein to each other, is the first point to decide in feeding any given case; the caloric value of the daily ration can be increased or diminished by changing the amount at each feeding or the number of feedings.

In the "caloric method" of feeding, so called, the total number of calories necessary per day is first determined, and the mixture is made up in such a way as to furnish the required calories, allowing a certain number for each ounce of whole milk, cream, or sugar used. There are several objections to

this way of feeding. In the first place, the caloric needs of different babies vary so much that the fact of supplying a theoretically correct number of calories in the mixture is no criterion whatever that the baby will gain. Second, the caloric method does not take into close enough account the composition of the food, and it is possible to secure an equal number of calories from mixtures which are widely different in their composition, and which might or might not be suitable for the baby. The following three formulæ contain the same number of calories; Mixture No. 1 would be a suitable feeding for a baby of three or four months, Mixtures No.s 2 and 3 would be utterly unsuitable.

	Fat. Per cent.	Sugar. Per cent.	Protein. Per cent.
No. 1	3	6	1.50
No. 2	5	2	1.50
No. 3	0	11	2.50

(Ladd.)

It is often useful, however, to calculate the calories in the daily feeding after its composition has been determined, and such calculation is often valuable as a check, if one is not quite certain whether or not he is covering the theoretic caloric needs (see Chapter VI).

General Plan of Feeding.—The artificial feeding of the normal baby during the first year may be divided into three stages:

1. From birth to the end of about the third week: In this stage a very weak food is used at first, in very small amounts, which is rapidly increased until a permanent formula, upon which the baby can gain weight, is reached. This newborn period I like to speak of as the "stage of establishing the food tolerance."

2. From the third or fourth week up to the eighth or ninth month: This is the stage when the baby gains most of his weight. There are relatively few changes made in the formula during this period, the most important being the gradual raising of the protein.

3. From the eighth or ninth month to the end of the first year: During this period a change is made from gravity cream and skimmed milk mixtures to concentrated whole milk dilutions, which are gradually increased until whole milk is reached at about the end of the first year. Other foods besides milk are also added at the beginning of this period.

The Newborn Period.—Newborn babies are not easy to feed artificially; they do not gain weight so rapidly or so regularly as breast-fed babies, and are very prone to digestive upsets. Furthermore, once a newborn baby has developed a digestive upset, it is often exceedingly difficult to correct it. The principal thing to remember is to start with a very weak food in small amounts, and to strengthen it at frequent intervals, until the baby is on a food which will cause him to gain weight. A newborn baby should always be underfed for the first week. It must be remembered, however, that his tolerance for food increases rapidly, and he must not be kept too long on a weak food. For the first twelve hours the newborn baby should be given nothing but water. A solution of lactose or of cane-sugar is often given, with no good reason. Nature intended that a baby should have no food for the first few hours, and if a sugar solution is given it is possible to initiate undesirable fermentation in the intestines and to interfere with the normal development of the intestinal flora. This has been especially emphasized by Czerny.

Table I shows in a general way what most newborns would be fed:

TABLE I

First Nutritional Period (One to Three Weeks)

Age, days.	Fat.	Sugar.	Protein.	Amount, ounces.	Interval, hours.	Number of feedings.
1	1.50	5	1.00	$\frac{3}{4}$	2	10
2	1.50	5	1.00	$1\frac{1}{2}$	2	10
5	2.00	6	1.00	$2\frac{1}{2}$	$2\frac{1}{2}$	8
10	2.50	6	1.00	3	$2\frac{1}{2}$	8
21	3.00	6–7	1.25	$3\frac{1}{2}$	$2\frac{1}{2}$	8

By this time, in most cases, the baby will have regained his birth weight, and should be gaining regularly. The last strength

of formula suffices most babies for a considerable period, and if a sufficient gain does not result, it is better to increase the amount at each feeding rather than the strength of formula. Newborns will almost always do better on a boiled formula than on a raw, therefore for the first three weeks, at any rate, the formula should be boiled vigorously for from three to five minutes.

Second Period: Three Weeks to Nine Months.—It is in this period that the baby does most of his growing. At the beginning of this period the night feeding should be omitted, and the last feeding given at 9 or 10 P. M. It is well, when breaking off the night feeding, to give an extra ounce at the 10 P. M. feeding, and this extra amount may be enough to carry the baby through the night without difficulty. It is desirable, if possible, to have the night feeding omitted before the obstetric nurse leaves, as in this way the mother is saved considerable trouble.

Table II shows in a general way how the food would be increased from the first to the ninth month. It must be distinctly borne in mind, however, that no tables can cover all cases, and that wide variations may be necessary for individual babies.

TABLE II

THE "GROWING" PERIOD: THREE WEEKS TO NINE MONTHS

Age, months.	Fat.	Sugar.	Protein.	Starch.	Amount, ounces.	Interval, hours.	Number of feedings.
1	3.00	6–7	1.25	....	4	$2\frac{1}{2}$	7
2	3.00	7	1.25	....	$4\frac{1}{2}$	$2\frac{1}{2}$	7
4	3.00	7	1.50	....	6	3	6
6	$\begin{Bmatrix}3.00\\3.50\end{Bmatrix}$	7	1.75	0.75	7	3	6
8 to 9	$\begin{Bmatrix}3.00\\3.50\end{Bmatrix}$	7	$\begin{Bmatrix}2.00\\2.25\end{Bmatrix}$	0.75	8	3	6

It is not advisable to change the formula often; if the baby is gaining weight, it is much better to leave it alone. Care must be taken, however, that the mother reports regularly at stated intervals, so that the food may be increased if necessary.

It will be noted that in this period the chief change in the composition of the food is the gradual increase in the protein (and hence calcium) to allow for the growth needs.

The Third Period: Nine Months to One Year.—At this time the gravity cream and skimmed milk mixtures are discontinued, and whole milk dilutions are substituted. The usual formula at nine months would be

Whole milk..............	36 ounces
Barley-water.............	12 ounces
Lactose..................	4 level tablespoonfuls

Six feedings of 8 ounces each.

The percentage composition of this formula equals fat 3, sugar 6.50, protein 2.40, starch 0.50. From now on it is not necessary to express the formula in percentages, and the amount of barley-water is gradually reduced and the milk increased, until whole milk undiluted is reached at about eleven or twelve months. If the mixture is boiled some babies can take it before this. When whole milk is reached the sugar is omitted.

Feeding with Whole Milk Mixtures from the Start.—If it is desired to use whole milk mixtures from the beginning, instead of gravity cream and skimmed milk formulas as described above, the feeding would proceed somewhat in accordance with the table below, the amount at each feeding and the interval between feedings being about the same as with the other method. In using whole milk dilutions a high concentration of milk is given at a comparatively early age, and for this reason it is well, when feeding a baby by this method, to boil the mixture in order to render the casein curd more digestible. It is possible to feed a good many normal babies successfully in this way, but, as has been said before in another chapter, it has its disadvantages.

				Percentages,		
Age.	Milk.	Water.	Added sugar.	Fat.	Sugar.	Protein.
2 days...............	$\frac{1}{3}$	$\frac{2}{3}$	Up to 5 per cent.	1.30	5.00	1.1
4 to 6 weeks..........	$\frac{1}{2}$	$\frac{1}{2}$	Up to 7 per cent.	2.00	7.00	1.60
4 months............	$\frac{2}{3}$	$\frac{1}{3}$	Up to 7 per cent.	2.60	7.00	2.20
7 months............	$\frac{3}{4}$	$\frac{1}{4}$	Up to 7 per cent.	3.00	7.00	2.40
10 to 11 months.......	Whole	0	None	4.00	4.50	3.20

It must be again repeated that any tables give only a general idea of what is suitable for the *average* baby, and in many individual cases the proportions given in the tables might not be at all suitable.

Solid Food.—At the eighth or ninth month it is well to begin cereal, fed from a spoon, partly to furnish additional nourishment and partly to teach the baby how to eat. A great deal of trouble is often experienced in teaching babies to eat semisolid or solid food. If spoon feeding is begun early, this trouble is minimized. Farina, strained oatmeal, or barley jelly can be used as the cereal, and most babies at nine months can take 2 or 3 tablespoonfuls a day without any trouble. Three or 4 ounces of a meat soup with a little rice in it may also be given at about this time on a small piece of zwieback softened with milk. Beef juice may also be begun at nine months, and can be alternated with the soup. Not more than 2 ounces a day should be given.

Green Vegetables.—I sometimes have carrots or spinach cooked in the soup, and then removed by straining, before the soup is given to the baby. In this way he gets a considerable amount of the iron content of the vegetables without the irritating and indigestible cellulose. I do not believe in the practice of feeding green vegetables or potato to young babies, and can see no good reason for it, although it is done by a good many well-known pediatrists. The practice originated in Germany, probably with Heubner, who, on account of the lack of iron in cow's milk, in 1895, at the Congress of Internal Medicine in Munich, advised giving a teaspoonful of spinach a day to babies of nine or ten months. Czerny likewise advised it, and laid especial stress on using not more than a teaspoonful or two, having it very finely ground, and not beginning to use it until nine or ten months. In this country, in recent years, the practice of giving vegetables to small babies has been pushed to an extreme, and we often see babies of seven or eight months who are taking large amounts of potato and other vegetables. It is undoubtedly true that some babies have such strong digestions and tough digestive

tracts that they can stand this sort of feeding, but many babies will develop severe chronic intestinal indigestion if given large amounts of vegetables, especially potato, at too early an age. There is no harm in giving small amounts of spinach purée to small babies as a definite therapeutic measure in anemia, but in my opinion there is absolutely no excuse or rationale for potato, squash, turnip, carrots, string beans, etc. There can be only two reasons for the procedure brought forward by its exponents:

1. That the vegetables supply vitamins which will reduce the danger of scurvy and possibly of rickets.

2. That they supply "salts," and that the baby needs more "salts" than are supplied him by farinaceous food and milk.

1. As far as scurvy is concerned, there is no better antiscorbutic than orange juice. If the baby is fed on fresh raw milk he does not need even this. If he is fed on a cooked milk he does need it, and usually takes it well, without running the risk of digestive disturbance that the vegetable feeding carries with it. Raw orange juice, moreover, is a much more powerful antiscorbutic than are either raw or cooked vegetables.

As regards rickets, small babies fed carefully on suitable milk modifications with the addition of cereal, soup, and possibly beef juice after the age of eight months, do not develop it. There is no good proof that rickets is caused by lack of vitamins or that green vegetables will prevent it. Furthermore, cow's milk contains an abundant supply of both the fat-soluble "A" and water-soluble "B" vitamins. These are much more stable than the antiscorbutic vitamins, and it has been shown that they are little if any affected by heating of the milk. Thus we see, that as far as vitamins are concerned, the baby may be amply supplied with them without the use of green vegetables. In the *treatment* of already developed rickets, green vegetables possibly have some value, in just what way is not clear; as a prophylactic they are not necessary.

2. As regards salts, cow's milk is so rich in this respect, with the exception of iron, of which it contains only traces, that

there can be no question of the baby's receiving an insufficient supply of salts, with this possible exception. *We come, then, to the only real reason for feeding green vegetables to young babies;* that is, the small iron content of cow's milk. It is a clinical fact that well-cared for bottle-fed babies do well and do not get anemic during the first seven or eight months with milk as their only food. This is evidence that the small amount of iron in cow's milk plus the reserve supply contained in the liver is sufficient to cover their iron needs during this period. It is also a clinical fact that babies who are kept on an exclusive milk diet after the eighth or ninth month soon become anemic and flabby and do poorly. This is presumptive evidence that cow's milk does *not* contain enough iron to supply the iron needs after this period, and that additional iron-containing food of some sort should be added. What foods shall be used? Is it possible to cover the iron needs with cereals and beef juice, or must we turn to vegetables? There are no figures available which indicate the iron needs of babies. Cow's milk contains about 0.6 milligram of iron to the liter, human milk, about 1.6 milligrams. Even breast milk, therefore, contains only a very small amount, and the iron needs of a baby must be very small. Morse[1] has calculated, using the adult iron needs for a standard, that a liberal estimate of the iron needs of a baby of 25 pounds is 0.0025 gm. daily. This is about one and one-half times the amount of iron contained in a liter of breast milk, and would seem to be a not unreasonable estimate. Is it possible to supply this amount of iron by means of milk, cereal, and beef juice?

	Iron, gm.
1 liter of cow's milk contains	0.0006
1 ounce of beef juice contains	0.0019[2]
3 tablespoonfuls of cooked cereal contain	0.0009[2]
	0.0034

These figures show that it is possible to considerably increase the amount of iron in the diet without the use of vegetables, and clinically it is a fact that babies fed in this way up

[1] Jour. Amer. Med. Assoc., vol. 74, 1920. [2] Ibid.

to the thirteenth or fourteenth month do not become anemic, and do well. If vegetables are given, spinach is the only one which has any excuse for being used, as it is the only vegetable which contains enough iron to amount to anything, and a few teaspoonfuls of well-strained spinach daily in the form of a purée should do no harm after the ninth month, but in most cases it is not necessary.

Amount at Each Feeding.—Babies vary a great deal in the amounts which they need at each feeding in order to be satisfied. A baby would naturally take more at each feeding if fed every three hours than he would if fed every 2½ hours, and the twenty-four-hour amount of milk must always be borne in mind if the intervals between feedings are to be changed. In general, in the first few weeks the amount given at each feeding has to be increased very rapidly, then more slowly. It is not possible to say exactly how much any baby, particularly a young one, needs; and if he is not satisfied with his feeding, the amount of the feeding should be increased ½ ounce at a time until he *is* satisfied. Spitting up is the first sign that he is getting too much, and if he does this, drop back to a smaller amount at each feeding, and later increase the strength of the food. As regards amount, pediatricians in general are rather prone to give too little. I am accustomed to give my mothers a good deal of latitude in this respect, and within certain limits to allow them to regulate the amount at each feeding themselves. A baby of two months should not take *more* than 5 ounces, a baby of four months more than 6 ounces, or one of six months more than 8. Babies of nine or ten months often will take 9 or 10 ounces, particularly if fed at four-hour intervals, but should never be allowed to take more than this. The size of the stomach at different ages is no guide whatever to the amount that can be taken at each feeding, for a considerable amount of the first part of the feeding leaves the stomach before the last part enters it. No baby should take more than 48 ounces in total quantity per day, and if he is not satisfied with this it is time to begin to give him solid food.

Interval.—For babies in the first three weeks of life small amounts of food at frequent intervals (2 to 2½ hours) seem to work best; after this period the three-hour feeding will usually be most satisfactory. If it is desired to get a little extra food into a baby who will not take large amounts at one time, babies of four or five months may often be fed with advantage every 2½ hours. The four-hour interval I do not believe in for most bottle-fed babies, as in order to get enough in total food value with such infrequent feedings it is necessary to feed them large amounts of a very concentrated food. In the case of unusually large, robust babies, however, this carries with it no objection.

Amounts of the Food Elements to Use.—*Fat.*—The usual dictum is, not to feed more than 4 per cent. of fat to any baby. I rarely use more than 3, and never as much as 4; 3 per cent. is enough for the vast majority of babies, and one runs much less risk of a fat upset than if more is used. If more fat is given the protein must be kept low, for high fats and proteins do not go well together. Two of the first symptoms of overfeeding with fat are loss of appetite and spitting up. It is not at all uncommon to see babies being fed on a cream dilution containing 5 or 6 per cent. of fat, when the physician in charge has simply given directions for diluting the "top of the bottle," and has not figured the fat percentage of his mixture. In using any cream or cream and skimmed mixture it is always necessary to know the percentage of fat in the original cream used and in the resulting mixture.

Sugar.—Most of the books say never to use over 7 per cent. of sugar. This is, in the main, a good working rule, but may often be advantageously broken. There are many babies, normal and abnormal, who are not gaining well on 7 per cent. of sugar, and who need just a little more carbohydrate for fuel. As much as 8 or 9 per cent. may be given to these babies without harm, and with considerable increase in weight and well being, provided the fat and protein in the mixture are not too high. If a baby's stools are alkaline in reaction, and smooth and formed, it is practically always safe to give him more sugar. If

they have a tendency toward looseness and are acid, be careful of it. In feeding high sugars it is best to use a combination of sugars, such as lactose and dextrimaltose, rather than one sugar alone.

Starch.—Although it has been shown many times that starch can be digested to a certain extent by newborn babies, it is not ordinarily given until the sixth or seventh month, although in special cases, where the sugar tolerance is low, and it is desirable to increase the food with some less easily fermentable carbohydrate, it may be used much earlier than this. The usual amount employed is about 0.75 per cent. With most normal babies, however, there is no particular reason for starting starch before the eighth or ninth month.

Protein.—In most of the ordinary milk mixtures a baby receives an adequate supply of protein, and if enough fat and carbohydrate is given to supply his fuel needs, there is little danger of underfeeding in this respect. A one-third dilution of the protein of cow's milk gives about 1.20 per cent. of protein, which is all there is in breast milk, and I have seen a few babies do well on this amount up to the sixth or seventh month. In general, however, it is better after the third month to begin to increase the protein, and most babies at eight months would be taking 2 or 2½ per cent. It must be remembered that whenever we increase the concentration of the milk in order to increase the protein we increase the salts as well. A small baby who could take perhaps 3 per cent. of fat and 1.50 per cent. of protein without trouble, gets into difficulty as soon as the protein is raised to 2.50 per cent., whereas he might be able to take the high protein perfectly well if it were not for the high fat. It is very probable that it is not the protein alone which causes this trouble, but also the increase of calcium which goes with any increase of protein.

Alkalies.—It is not usually necessary to add an alkali to the food of the average normal baby, unless he is being fed on an unusually high protein percentage, in which case sodium citrate or lime-water may be used, in accordance with the directions

given in Chapter IX. Some quite normal babies, however, as soon as the protein in their food gets up to 2 or 2.50 per cent., will show casein curds in the stools. In these cases it is well to use an alkali or to boil the milk.

Gain in Weight.—There are fat normal babies and lean normal babies, as there are fat and lean normal adults, and the fact that a baby is slightly below the average weight for his age does not necessarily mean that he is not doing well, provided his flesh is firm and pink, and that he is doing well in other ways. Conversely, a very fat baby is not necessarily healthy, and, as a matter of fact, excessive fat is no more desirable in a baby than in an adult. There are babies who grow very fat on a comparatively small amount of food, and others who are always perfectly healthy, but never very fat, no matter what they are fed on. There are so many variations in the individual that averages are likely to be somewhat misleading, but the average baby will double his birth weight at five months, and treble it in a year. A good many carefully fed babies in private practice will do considerably better than this.

The following table from Griffith[1] shows the average weights of normal breast-fed babies at different ages:

Age.	Weight.	Age, months.	Weight, pounds.
At birth	7 lbs. 8 oz.	5	15
1 week	7 lbs. 7½ oz.	6	16¼
2 weeks	7 lbs. 10½ oz.	7	17¼
3 weeks	8 lbs. 2 oz.	8	18¼
1 month	8¾ lbs.	9	18¾
2 months	10¾ lbs.	10	19¾
3 months	12¼ lbs.	11	20⅓
4 months	13¾ lbs.	12	21½

Daily weighing for the first three weeks is desirable; after this it is not well to weigh more than once a week, as a slight loss or no gain may upset the mother too much. With a normal baby during the first few months gains in weight of from 5 to 8 ounces should be registered each week; after this the weekly

[1] Diseases of Infants and Children, W. B. Saunders Co., 1919.

gain is not so great. No baby gains the same each week, and often a normal baby may do only 2 or 3 ounces one week, and make it up by a large gain the next. Small gain for one week does not necessarily indicate that the baby is doing poorly; small gain for longer than this indicates that something is wrong. Either the baby is being underfed, is having indigestion of some sort, or is not gaining on account of poor appetite possibly caused by beginning rickets, teething, or a cold in the head. If a normal baby gains steadily more than 8 or 9 ounces a week it is usually best to reduce the food somewhat, as this is an indication that it is being pushed nearly to the limit, and indigestion may soon develop.

Weights of Older Children.—The table below[1] shows the average weights in children from one to five years of age. These are somewhat below the figures that may be expected for robust children of the upper classes in private practice.

Age.	Weight, pounds.
Twelve months	22.1
Thirteen months	22.5
Fourteen months	23.3
Fifteen months	23.9
Seventeen months	25.2
Eighteen months	25.3
Nineteen months	26.1
Twenty months	26.5
Twenty-one months	26.3
Twenty-two months	26.8
Twenty-three months	27.5
Two years	28.0
Three years	32.9
Four years	36.1
Five years	41.2

There has in the last few years been a nation-wide movement to weigh and measure all children in order to detect malnutrition, which, in the main, is commendable, but there has been altogether too much tendency to feel that a child must conform to the theoretic weight requirements in order to be

[1] Griffith, quoted from Camerer.

considered in satisfactory condition. This is by no means so; many perfectly healthy children are naturally thin. Also the children of small parents, those who have small frames, small hands and feet, are likely to weigh somewhat less than the children of large parents, and a great deal of unnecessary worry is caused a mother on account of the fact that her baby does not weight as much as her neighbor's naturally larger child.

Stools.—The stools of a normal artificially fed baby vary according to what type of mixture he is fed on, but in general are from one to three a day in number, rather pasty and formed in a good many cases, and slightly foul smelling. Mothers worry a good deal about constipation, but a slight tendency toward constipation should always be a welcome sign to the doctor. A little constipation is of absolutely no harm to a baby, provided it is not enough to make him uncomfortable. Many text-books and mother's manuals are explicit in laying down the rule that a baby *must* have at least one movement every twenty-four hours, and this statement has caused a great deal of worry to young mothers and trouble to doctors. It is natural for a bottle-fed baby to be a little constipated, and a mild constipation does him more good than harm. There are many well babies who often skip a day without having a movement, and provided it does not give them gas and colic, there is no necessity of doing anything about it. No baby should be allowed to go for forty-eight hours without a movement, however, and the best way of bringing this about is by a simple soapsuds enema or a teaspoonful of milk of magnesia. Suppositories are not good for continued use, and I have only recently seen a bad case of proctitis brought about in this way. If the constipation becomes more than is normal, a decrease in the protein of the food, and an addition of a couple of tablespoons of Malt Soup Extract to the total daily feeding will often correct it. If the constipation be excessive, or if it is due to the formation of white "soapy stools," it is pathologic, and will be discussed under the proper headings.

There is no normal baby who does not occasionally, espe-

cially during periods of warm weather, have an occasional loose stool. If the strength of the food is immediately reduced for three or four feedings this is usually the end of the trouble, and often a serious fermentative diarrhea may be avoided if this is always done immediately on the appearance of such a stool. Usually diluting whatever formula the baby is taking one-half with water is sufficient.

The Urine.—Many normal babies fed on high proteins are very likely to have a very ammoniacal urine. This is of a different type from the ammoniacal urine seen in cases of fat indigestion, and usually is cleared up by reducing the amount of protein in the food and increasing the carbohydrate.

Water.—If babies under a year old like water, they may have it; if not, it is not necessary to force it upon them, as they get a great sufficiency of water for all their metabolic needs in the comparatively large amount of milk they take each day. If an adult weighing 150 pounds took as much fluid in proportion to his body weight as is taken by a 15-pound baby in a quart of milk a day he would take about 9 quarts. If a mother who calls up and says "My baby won't take water, what *shall* I do?" is simply told this ratio, her fears are at once forever quieted.

Orange Juice.—A tablespoon or two of orange juice is ordinarily added to the diet at about the third month. This is necessary if the baby is taking a boiled or a pasteurized milk. It is not a necessary part of the diet if raw milk is used. Orange juice is commonly supposed to be laxative, but, as a matter of fact, it has but little laxative action in most babies. In a few cases it acts as a most efficient laxative, however.

Orange juice should be given about an hour before the feeding. It can be diluted with water, or may have a little cane-sugar added to it if the baby prefers it this way. If it causes "spitting up," sometimes the addition of a small amount of lime-water will prevent this.

Spitting Up.—A great many normal babies spit up a mouthful or two after some of their feedings. This may mean that the total quantity ingested is too great, or it is very likely to mean

nothing whatever, and if the baby is doing well, having good stools, and gaining weight, it is not necessary to pay any attention to it. Babies fed on a malt sugar preparation are the ones most likely to do it.

Gas.—Every normal baby has a little gas occasionally, and passes it either by mouth or rectum, or retains it, in which case he has colic. The best treatment for discomfort from gas is:

1. Holding on the shoulder, and patting the baby's back in order to force the gas from the stomach.
2. A soda-mint tablet, dissolved in a tablespoonful of warm water.
3. A soapsuds enema.

Crying.—Every baby, normal or abnormal, cries considerably. It is the only way he has of expressing himself; it is his most important mode of exercise. Normal babies vary greatly in the amounts of crying they do, some are naturally "good," while a few, although perfectly healthy, cry a good part of the time, and make life miserable for the mother or nurse. A large part of this trouble is caused by faulty training, and it is often difficult to make the mother understand that there is nothing the matter with the baby when he is probably merely crying from temper or because he is lonesome. If a crying baby is doing well as regards his feeding, is not sick, and stops crying the minute he is picked up, he can safely be left to "cry it out," and should be so left. It will do him no harm, and in my opinion one of the most important duties of the obstetric nurse is to have the baby well started on the right training before she leaves the house. The time to start is as soon as the cord is tied.

General Condition.—A well baby, whose nutrition is progressing satisfactorily, has a pink skin and firm flesh. The "tissue turgor," so called, or the firmness of the flesh, is one of the most important indications of the satisfactory state of his nutrition. I always like particularly to look at the legs and buttocks of babies to determine the firmness of the flesh, and well-rounded, firm, pink buttocks usually mean a good state of

nutrition. Very little can be told from the face; many babies whose flesh is soft and flabby may have round, fat faces. Furthermore, many apparently fat babies, who weigh more than the average for their ages, may be, in reality, in a very poor state of nutrition, which is evidenced by their pallor and the flabby condition of their flesh. Babies fed on condensed milk or on very high carbohydrate diets containing too small an amount of protein are very likely to be of this type, and the excess weight is due, in reality, to water retention brought about by prolonged overfeeding with carbohydrate. These babies bear illness very poorly, and lose weight rapidly during any infection or acute digestive disturbance.

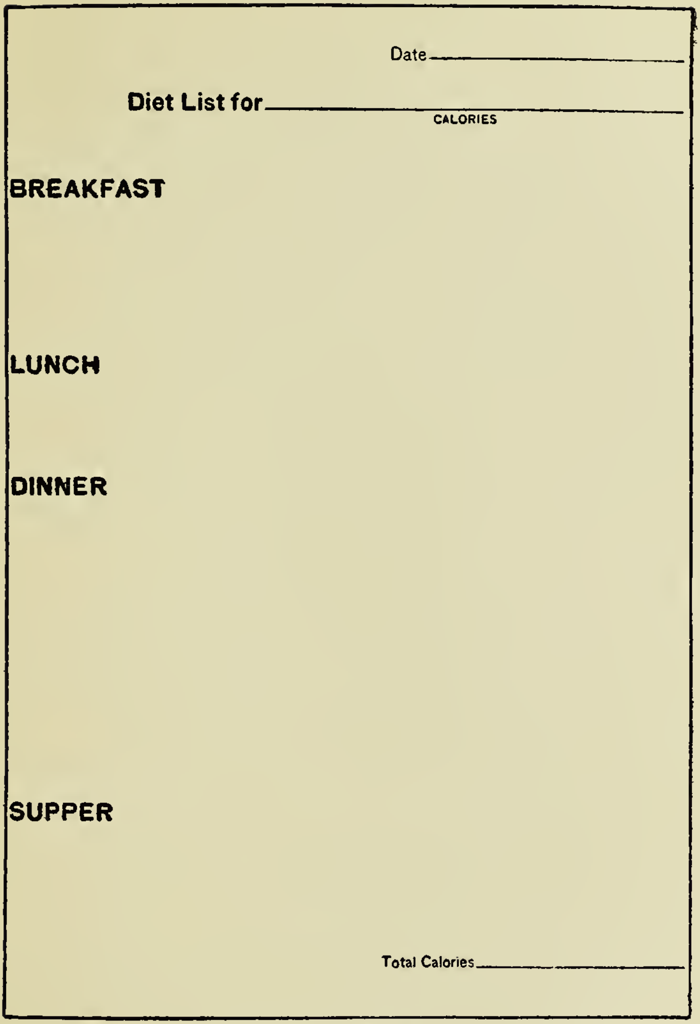
Babies vary a great deal in the amount of "color" they show in their faces. It is the ambition of every mother to have a baby with rosy red cheeks, and, of course, a great many well-fed, robust babies are of this type, but others equally healthy, of the same weight, and with the same tissue turgor, may have color only occasionally, and may look rather pale at other times. This does not necessarily mean that there is anything wrong with the baby; it probably has something to do with the state of the vasomotor system and the texture of the skin, and also probably a good deal to do with heredity. Many people naturally have little "color," and babies are likely to resemble their parents in this respect.

A great many babies begin to cut teeth at six or seven months, but many normal babies will not begin until a month or two later than this. One should always think of a mild rickets in connection with late dentition, but evidences of this are by no means always found, and I have seen one perfectly normal, well-developed baby without the slightest sign of rickets, who never cut a tooth until she was fourteen months old. One pediatrician of experience has said that all bottle-fed babies have a little rickets, and it is certainly true that many babies in whom one can find nothing whatever to criticize have a slight rosary, a slightly delayed closure of the fontanel, and a somewhat tardy dentition. In the majority of cases the rachitic

process, if one really can call it such, never goes any further, but it is a good plan to give such babies cod-liver oil in doses of 15 or 20 drops three times a day, and to watch carefully for any further signs of rickets.

FEEDING DURING THE SECOND YEAR

In general, mothers are altogether too prone to feed babies of this age too great a variety of foods. A baby does not need a particularly varied diet; if he is normal mentally and physically he goes contentedly along from day to day on very much the same general plan of diet. The modern tendency is to introduce too many articles of food into the dietary at altogether too early an age, and is the biggest part of the reason why babies get into so much trouble during the "second summer." Most babies will flourish on milk, cereals, zwieback, soup, or beef juice and orange juice until they are fourteen months old, and there is no advantage in giving them anything else. Cereals should be taken with a little milk poured over them, but with no sugar. While it is probably true that a small amount of sugar on the cereal does not at the time do any harm, it is not wise to get the child in the habit of taking sweet things, and if he is not used to sugar, he never misses it. The best cereals for babies are barley jelly, farina, oatmeal, or rice. Babies usually like soup. Whether or not it is of any real value is doubtful. If it has any value, it is probably due to the small amount of iron that it may contain, and it is well to have soup made with carrots or spinach cooked in it, and then strained out again, to get whatever advantage there may be in this. A neck of lamb is as good as anything from which to make soup, and has the advantage of cheapness. A pound and a half will make a pint of good soup. Usually not more than 3 or 4 ounces of soup is given at a feeding, with the noon meal, and a tablespoonful of rice or pearl barley (measured when cooked) is given with it. Beef soup is not so digestible as lamb or chicken. Zwieback or dry bread is valuable, and part of the daily ration of zwieback



Date ______________________

Diet List for ______________________ CALORIES

BREAKFAST

LUNCH

DINNER

SUPPER

Total Calories ______________________

Fig. 4.—Diet card.

ought to be given dry, as it teaches the baby to chew. In planning a diet for a baby it is much better to put down on paper for the mother exactly what he is to have, and exactly when he is to have it, than merely to write down or to give instructions

verbally. For some years I have used cards of 5 x 8 inches, one of which is reproduced on p. 247. These can be mailed, with everything put down in black and white, so that there is no chance for a mistake, and are especially convenient for use after the mother has called up to inquire about the diet over the telephone, or for those patients whose feeding is being regulated by letter.

Beef Juice.—The chief value of beef juice is to furnish iron. It also contains a certain amount of protein (about 6 per cent.). It is best given at the noon meal poured over bread, toast, or potato. Not more than 2 ounces a day should be taken.

Green vegetables may usually be started safely at fourteen months, and should always be strained through a fine sieve, so that they are in the form of a fine paste. The best vegetables to use are spinach, carrots, string beans (if tender), and peas. The chief value of the green vegetables at this age is to add bulk to the diet and also to furnish iron. Portions of any vegetable, particularly spinach and carrots, always come through in the stools, and this is of no moment unless a diarrhea is caused, in which case the vegetables should be discontinued until the child is a little older. The vegetables are usually given at the midday feeding, mixed with soup and rice. In some cases, if the baby is anemic, I add the grated yolk of a hard-boiled egg for the iron that it contains.

The foregoing is a middle stand with regard to the vegetable question, and while I do not believe that young babies should take them, neither do I believe that they should be withheld until the end of the second year, or even later, as some authors advise. When a baby gets to be fourteen or fifteen months old he needs a fairly bulky diet, and the addition of vegetables brings this about, and thus minimizes the danger of feeding him too much starchy food. At fourteen months a well baby would be on the following diet.

6.30–7.00 A. M. (on waking): Milk, 8 ounces.
9.00 A. M.: Orange juice, 2 ounces.
10.30 A. M.: Cereal, 1 cupful.
Milk, 8 ounces.
2.00 P. M.: Soup, 4 ounces, or beef juice, 2 ounces.
Green vegetable, 2 tablespoons } mixed
Strained rice, 2 tablespoons } together.
Junket.
Milk as much as he wants, with a slice of stale bread.
6.00 P. M.: Milk toast or zwieback softened in milk.
Apple or prune sauce, 2 tablespoons.
Milk, 8 ounces.

Potato and Eggs.—Many babies digest potato with difficulty, and they are usually so fond of it that they often take a good deal more than they should. We have all seen babies who take a baked potato every day at one year, and thrive on it, but, in general, it is best to wait until sixteen months before starting it. Baked potato is the most digestible form, and one potato a little larger than an egg may be taken every other day, with a little milk poured over it. It is best *not* to give potato on the same day that the green vegetable is given until a baby is about 2½ years old. A number of babies have an idiosyncrasy to egg, and when the first taste of egg is given will break out with an urticarial eruption, and may be violently sick. Other babies have no idiosyncrasy to egg in the sense of allergy, but it merely upsets their digestions and causes diarrhea or vomiting. In the first case the trouble is usually due to the white of the egg, and if skin tests are done it can easily be determined whether the white or the yolk, or both, are at fault. If the idiosyncrasy is to the white alone, the yolk may be given hard boiled and grated, mixed with the green vegetable and rice. In a great many cases after a few months the child will be able to take the white without trouble. If not, it is possible to desensitize by feeding very small doses of powdered egg-white. In the second case it is best to wait a few weeks, and then try the egg again in small doses.

Egg should be always started in small portions, a teaspoonful at a time, until one knows how the baby is going to react to it,

then as he becomes used to it he can take one egg every other day, usually at the 2 o'clock feeding.

Diet from Sixteen Months to Two Years

6.30–7.00 A. M.: Milk, 8 ounces, with a small cracker.
9.00 A. M.: Orange juice, 2 ounces.
10.30 A. M.: Cereal, 1 cupful.
Milk, 8 ounces.

	One day.	*The next day.*
2.00 P. M.:	Soup, 3 to 4 ounces. Potato, egg. Junket. Milk(?).	Soup, 3 to 4 ounces, or beef juice, 1 to 2 ounces. Green vegetables, 2 tablespoons. Rice, 2 tablespoons. Custard. Milk(?). Bread and butter.

6.00 P. M.: Milk-toast or zwieback and milk, or bread and jelly sandwiches, or macaroni.
Apple or prune sauce or stewed pears.
Milk.

Diet for a Child of from Two to Three Years

8.00 A. M.: Cereal.
Egg.
Toast.
Milk.
11.00 A. M.: Milk, 8 ounces.

	One day.	*The next day.*
1.30–2.00 P. M.:	Soup(?). Vegetable: string beans, spinach, carrot, squash, peas, turnip. Rice or macaroni. Bacon. Tapioca pudding, junket, or custard.	Soup(?). Vegetable. Potato. Meat: chicken, beef, lamb. Tapioca pudding, junket, or custard.

6.00 P. M.: Milk-toast or zwieback and milk, or bread and jelly sandwiches. Cereal occasionally. Milk. Apple-sauce, prune sauce, baked apple, or stewed pears.

At about two years the baby begins to have a regular breakfast at 8 o'clock instead of his early bottle. Meat and

bacon can be added to the diet at this age. The meat should be finely scraped, and may be chicken, lamb, or beef. Beef is the least digestible of these three. Crisply cooked bacon can be alternated with the meat, and either the meat or bacon is mixed with the vegetables and rice or potato.

A child's wishes should not be consulted or catered to in the matter of diet. It is common for children to refuse new articles of food offered, and if the mother is not persistent in the beginning she may have the greatest difficulty in getting the child to eat certain things. The child who "doesn't like this" and who "can't eat that" should not be seen in a well-regulated family. Many of the dietary troubles that occur in children from three to six years of age have their origin in the first three years when on account of the fact that the child at first refuses certain articles, he is never thereafter urged to eat them, and his poorly balanced diet is made up entirely of things which he does like, such as, perhaps, toasted corn flakes, potatoes, or milk.

CHAPTER X

DIGESTIVE AND NUTRITIONAL DISTURBANCES IN THE BOTTLE FED

(1) The science of infant feeding is a young one. (2) The problems involved in a consideration of the disturbances that may arise when a baby is being artificially fed are often extremely complicated. For these two reasons we know even now comparatively little about the exact nature of these disturbances, and it has not always been possible to keep speculation and fact as far apart as they should be kept. Hence there have been, as we have seen in the chapter on the Development of Modern Infant Feeding, various opinions regarding the nature of these disturbances, many of which have been discarded as knowledge has progressed. Our information is constantly being added to, and it must by no means be though that we have yet reached the stage where we have a fixed or even a satisfactory knowledge of the many problems involved. Development in different localities has been along divergent lines, and widely separated opinions have been held by various investigators, who have used different methods of nomenclature and classification. This has not tended to make the subject clearer to the casual student. In what follows I shall not try to follow any one school, but to present what seems to me to be a practical conception of the disturbances of digestion and nutrition in infancy in accordance with the present state of our knowledge. The six following propositions are fundamental:

1. The artificially fed baby is prone to digestive disturbance because cow's milk is chemically and biologically different from the food that nature intended him to take, and because it may be richer in bacteria.

2. Rarely is the disturbance primary in the digestive tract; it is not the digestive tract or its secretions which are at fault, but the food which is offered.

3. In considering the disturbances of digestion and of nutrition it is necessary to bear in mind that the food is made up of fat, sugar, starch (sometimes), protein, and salts, and to be able to trace the special sort of damage that may be caused by any one of these food elements individually. It has been found by experience that the different food elements may cause different sorts of disturbances, with symptoms which are, to a certain extent, characteristic of each element.

4. Not only is a consideration of each individual element important, but the quantitative relationship of these in the food offered must always be borne in mind, and while any given element in a certain amount might be harmless in one combination, it might cause considerable disturbance when offered in another.

5. Bacteria within the digestive tract can never be separated from problems of digestion and nutrition. These bacteria may be those which are normally inhabitants of the intestine, or may be introduced from without in infected milk. Bacteria play little part in gastric disturbances, but many times play the major rôle in intestinal indigestions. *If there is a residue of food which the baby is incapable of digesting and assimilating, this food is attacked by bacteria, and excessive fermentation or putrefaction results, which gets the baby into trouble.* This is one of the most potent of all sources of disturbance in artificially fed babies. Also if bacteria are introduced from without, and are present in the upper portions of the intestine, where they should not be, the same result occurs. If is often not possible to tell, in intestinal disturbances, how much of the trouble is due to bacterial decomposition of the food and how much to undigested food alone.

6. Acute disturbances, if checked, usually carry with them little disturbance of nutrition or of the body as a whole; they are localized in the digestive tract, and may be correctly spoken

of as "indigestions." Chronic disturbances often bring about severe nutritional damage, and an abnormal metabolism of the whole body. These are true disturbances of nutrition, and, as Czerny and Finklestein in particular have pointed out, may be looked upon as metabolic diseases, in the same way that diabetes is a metabolic disease. Here we are dealing with an indigestion plus far-reaching general bodily damage.

Classification and Nomenclature.—There is no subject in medicine at present in which a looser nomenclature is used than in infant feeding. If one studies the ten or a dozen text-books of infant feeding that are written in English, he will soon see that there is little uniformity of expression. This is a pity, as it tends to cause confusion. Clear and uniform classification and nomenclature are essential in any scientific subject. The two great dangers in any classification are those of including too many somewhat similar phenomena under one heading, or of splitting apart the subject into too many divisions, several of which might be better confined under one heading. A satisfactory classification strikes a happy medium between these two extremes. A satisfactory classification should serve at the same time as a system of nomenclature. It is true that one can correctly divide digestive disturbances in babies, as Marfan has suggested, into vomiting, diarrhea, constipation, and failure to gain. Such a classification includes all the cases seen, but is entirely unscientific, and is of no value in giving us a closely fitting descriptive name to apply to any given condition that we see before us.

It is possible to classify any group of phenomena or objects in a number of different ways; that is, metals or woods may be classified according to their hardness, color, weight, or innumerable other qualities. Likewise, it is possible to group digestive disturbances in infants according to their etiology, pathology, or clinical symptomatology. This has been done in the past, and there are at present in use classifications on all these bases, or on combinations of them. Any division has overlappings; in a classification of the sciences geology borders on physics and

chemistry; zoölogy, on botany; chemistry, on physics. It is likewise not possible in constructing a classification of the digestive disturbances of infants to do away with overlapping; there will always be borderline or mixed cases, no matter what method of classification is used. The three bases of classification that have been employed are those of pathology, clinical symptomatology, and etiology. A practical work of this sort is not the place for a detailed discussion of the advantages and disadvantages of each one of these groupings; it may be said that inasmuch as there are often no pathologic lesions to be found in babies dead of gastro-intestinal or nutritional disease, the pathologic classification cannot be accepted as a satisfactory one. The clinical classification has many good points, but since it is true that many times the same clinical picture may be produced by rather widely different etiologic agencies, it is open to objection on this score. The best classification is one which arranges its objects in a definite plan, which can also serve as a system of nomenclature, and which is best adapted to the purposes in view. In this particular instance the ultimate purpose in view is *treatment.*

The etiologic classification fulfils these requirements. It has its defects, but has fewer defects and more good points than either of the others. It includes all cases, it gives us a very serviceable nomenclature, *and especially does it focus our attention on the individual food elements, and gives us suggestions for treatment.* In many medical subjects an etiologic classification is not at all serviceable, but in the subject under discussion, where a careful consideration of each food element is so important, and where it is so necessary to know what symptoms each one produces, an etiologic nomenclature makes the subject much more clear. *Therefore, let us speak of digestive disturbances in terms of the food element that is the most active in causing the trouble.*

The following classification has its origin in that of Czerny, and with the exception of a few slight changes is the same as that used in the Harvard Medical School (1921). It is by no

means perfect, but will be found serviceable as a practical working basis:

1. Underfeeding
2. Acute fat indigestion
3. Acute sugar indigestion
4. Acute protein indigestion
5. Acute starch indigestion
6. Chronic fat indigestion { Type 1 → Type 2 →
7. Chronic sugar indigestion →
8. Chronic starch indigestion →

→ 9. Marasmus

The acute indigestions carry with them little disturbance of nutrition; the chronic forms, if severe, are accompanied by severe nutritional damage. The condition called "marasmus," which represents simply an extreme degree of malnutrition, may be brought about by prolonged underfeeding or by any one of the chronic indigestions if severe enough and if continued over a long enough period of time. It is a condition so distinctive, and possessing such especial characteristics, that it is best to look upon it as an end-result of prolonged digestive insult, and to realize that much the same final result may be produced whether it has been caused by underfeeding, or by starch, sugar, or fat, than to speak of it as a severe chronic indigestion of any one type.

Underfeeding.—This condition is not so common as many of the other disturbances, as the great tendency at present is rather to overfeed babies than to underfeed them. It is seen especially in babies who have been fed on proprietary foods, or on condensed milk mixtures, where the calories offered have not been enough to promote normal weight and growth development. It is seen in cases where the physician has prescribed during the early weeks of life a modified milk mixture low in fat and in protein, and has then lost track of the baby for several months. The baby has had no symptoms of indigestion, and has seemed to be doing fairly well, so the mother has continued with the same food, and the child is taking at seven or eight months a food which was adequate for him at one month, but which is not now sufficient. Another type of underfed baby is

one which has been fed over a considerable period of time on barley-water, or perhaps barley-water with a small amount of milk added. This is likely to be seen among the ignorant classes, where many mothers have a firm belief in the nutritive powers of barley-water. It is, of course, a very weak food.

Babies who have been underfed may vary a great deal in their appearance and in the severity of their condition, according to the degree and time of underfeeding. Many are only slightly underfed and only a little below average weight. They are rather flabby, with poor color and tissue turgor, and may or may not have signs of rickets. Their digestive powers are little if at all impaired, and they respond readily to treatment. The more severe cases may present the picture of extreme malnutrition. They are much emaciated, small in size, with small bones, and flabby, inelastic tissue. Their tolerance for food is low, largely because their digestive powers have never been developed, and partly because bacteria are likely to flourish high up in the digestive tract and either ferment or putrefy any undigested food residue.

Treatment.—The treatment of the milder cases is not at all difficult. It consists merely in increasing the caloric value of the diet. This should be done rather slowly, in order to gradually accustom the digestive tract to stronger food. The food is increased until it is sufficient to cover the caloric needs, and to bring about a gain in weight. If the baby is over eight or nine months old, the addition of other articles of diet, such as cereal, zwiebach, or beef juice, is often of value. The severe cases are much more difficult, as the food tolerance is low, and symptoms of indigestion are very likely to occur as the caloric value of the diet is increased. The best plan to follow is first of all to increase the protein to an amount which is sufficient, then the fat and sugar. The fat tolerance is almost always poor in this class of babies. If the sugar tolerance is good, much benefit often results from feeding a high sugar. One element only should be raised at a time, and it is likewise well not to increase the strength and the amount of the food at the same time. By

increasing only one food element at a time it is much easier to tell what has upset the baby if difficulties occur. If symptoms of indigestion are caused by the increase in diet, they should be treated with the proper treatment for that type of indigestion.

Acute fat indigestion is caused by overfeeding with fat, either as too high a percentage of fat, or as too much total food. There are very few babies who can take more than 4 per cent. of fat, and most small babies cannot take even this amount. Acute fat indigestion is especially likely to be seen in babies under two or three months of age, but may occur at any age. Vomiting of sour, thick, creamy material is one of the first symptoms. This is usually combined with loose, greenish-yellow stools, usually, but not always, acid in smell and reaction, which contain many large and small undigested fat curds. The number of stools is usually from three to six a day, and the buttocks soon become excoriated by them. The gastric disturbance is probably caused by the irritating free fatty acids in the excess of fat given, without the intervention of any bacterial processes, the diarrhea by the irritant action of the unabsorbed fat on the intestinal mucosa, and also probably by a certain amount of bacterial decomposition of the fat. The fat in the stools is usually in the form of fatty acid or soap, but in cases in which the overfeeding with fat has been excessive, the stools may be loaded with neutral fat. Under these conditions they are likely to be of a bright yellow color and oily consistency.

Treatment.—In any acute indigestion it is always well to stop milk for a few hours. The baby should be put on a weak barley-water decoction for six or eight feedings in order to rest the digestive tract. It is well also to give a dose of castor oil in order to thoroughly empty the intestine. The subsequent feeding can be either one of the following:

1. Boiled skimmed milk dilutions.
2. Protein milk (see Chapter IX).

If the stools are not very loose or frequent, and show little green coloration, the first method of feeding is satisfactory, and is much more simple than the second. A few ounces of the

barley-water feeding may be replaced by an equal number of ounces of skimmed milk, and the whole boiled together for five minutes. Usually about one-half barley-water and one-half skimmed milk would be employed in babies over two months old, giving a formula of fat .00, sugar 2.25, protein 1.60.[1] With younger babies a more dilute formula would be used, with water as a diluent instead of barley-water. The baby is kept on this feeding for a day or two, until the stools begin to improve, when sugar can be added, and lastly fat, rather cautiously, until an amount of fat is reached about equal to whatever amount of fat he had been previously doing well upon.

The duration of symptoms, and the time it will take to get the baby back to a diet upon which he can gain weight, depends entirely upon the severity of the case, and the time over which excessive fat feeding had been going on.

If the stools are very loose and green, not at all homogeneous, and contain a good many large soft curds, it is probable that a certain amount of sugar indigestion is associated with the primary fat trouble. In this case the first method of feeding is not as efficient as protein milk feeding (Finkelstein's original protein milk, a laboratory prepared precipitated casein mixture, or "larosan" or "casec" milk). With this method of feeding it is not usually necessary or desirable to remove the fat entirely, but a rather low fat is given in combination with a high protein (in precipitated form). In a couple of days this feeding produces, in most cases, smooth, rather constipated, putty-like stools. When this stage is reached, sugar may be added, and it ought to be possible in most cases to gradually work the baby back to an ordinary milk modification containing a rather low fat percentage in a few days.

Acute Sugar Indigestion.—It is probable that it is not possible for acute sugar indigestion to occur without a certain amount of bacterial fermentation of the sugar. Therefore acute sugar indigestion is very similar to fermentative diarrhea (see next

[1] This is the minimum. Often it is desirable to use a much greater concentration of skimmed milk than this

chapter). Sugar is the most easily fermentable by bacteria of all the food elements, and any unabsorbed sugar residue, whether present in the intestine on account of poor sugar digestion or overfeeding with sugar, is almost sure to be attacked by bacteria and fermented. There is no sharp distinction between sugar indigestion and fermentative diarrhea; they both represent, in reality, the same process, although they may be brought about in somewhat different ways. Sugar indigestion is a condition of relatively mild sugar fermentation; fermentative diarrhea, a severe one. In the second condition the products of excessive bacterial decomposition dominate the picture, and the stools are very loose and contain a great deal of mucus, and sometimes pus. In sugar indigestion these manifestations of extreme irritation of the intestine do not result. Sugar indigestion usually results from overfeeding with sugar, the unabsorbed portion of which is fermented by the bacteria normally present in the intestine—fermentative diarrhea usually from bacteria introduced from without in bad milk, or bacteria swallowed in abnormal nasal or pulmonary secretions. Sugar indigestion occurs at any time of the year; fermentative diarrhea, usually in the summer. In the Finkelstein classification both of these conditions would be grouped under "dyspepsia," and it is true that the somewhat indefinite distinction between them is a defect of the etiologic system of classification. The term "sugar indigestion" is then reserved for the milder forms of sugar fermentation; "fermentative diarrhea," for the more severe. A sugar indigestion is very likely to begin with the spitting up of thin watery material. This is particularly true if malt sugar preparations are used, and often a more severe disturbance may be prevented by recognizing this premonitory symptom and cutting down the sugar in the diet before intestinal symptoms have had a chance to develop. Most of the disturbance in sugar indigestion is, however, intestinal, and is shown by the passage of loose, green, acid stools, containing usually moderate amounts of mucus, and many small white curds of undigested fat, which has been hurried through the

intestine so fast by the increased peristalsis that digestion and absorption could not take place. These stools smell strongly acid, react acid to litmus-paper, and cause red, blistered buttocks. The baby is usually not very sick; he may, however, be fretful, have a certain amount of abdominal distress, and perhaps a degree or two of temperature. The mechanism of the production of acute sugar indigestion is that the undigested sugar is being attacked by bacteria either in the large or small intestine, is fermenting, and the acids, such as acetic, butyric, and formic, which are formed as a product of the fermentation, irritate the intestinal mucosa and cause an increased peristalsis, with loose, undigested stools.

Treatment.—A very mild sugar indigestion, where perhaps there have been only two or three moderately loose acid stools for a day or two, may be often successfully treated by simply diluting the modification with one-half water for a few feedings, by omitting added sugar from the modification, leaving the rest of it as it was before, or by withdrawing milk entirely for a day, and substituting a weak barley-water decoction. The reduction in the amount of sugar ingested is enough to stop the fermentative processes which are taking place, and to restore the normal bacterial balance of the intestine. This suffices, however, for only the mildest cases; all others should be treated by a radical change in the character of the food. The objects of treatment are first to empty the digestive tract of as much of the fermenting material as possible, and then to change the food in such a way that no more fermentation of sugar will take place. By withdrawing sugar, the material that is fermenting, and by substituting protein in relatively large amounts, a food which is not likely to be attacked by the same sorts of organisms that are attacking the sugar, and which is likely to set up an alkaline condition in the intestine instead of the excessively acid one already present, the desired purpose may be accomplished. A food containing a small amount of sugar and a relatively large amount of protein, such as Finkelstein's protein milk or one of its modifications or substitutes, fulfils these indications. It is

often a temptation to try to treat these cases by simply withdrawing sugar from the modification instead of changing the entire character of the food, but this is a mistake except in the very mildest cases, and much time will be saved if a low sugar, high protein milk is used from the beginning.

Details of Treatment.—1. Castor oil, 2 teaspoons.

2. Finkelstein's protein milk, dried protein milk, larosan milk, precipitated casein milk, or lactic acid milk dilutions, according to the circumstances of the case. A preliminary starvation with barley-water is not usually necessary in simple sugar indigestion. After a couple of days of feeding on the high protein milk the stools should become decreased in frequency, salve-like in consistency, and gray in color. When this stage has been reached, sugar may be gradually added, 2 per cent. at a time, until 6 or 7 per cent. has been reached. Dextrimaltose is the best sugar to use for this purpose, as it is less easily fermentable than lactose. In the ordinary case, where the baby has previously been healthy, it is not necessary to keep up the protein milk feeding for more than a week or so, when a feeding of the ordinary milk modification, with a rather lower sugar than it contained before, may be substituted for a bottle of the protein milk. Daily substitutions may be made until the protein milk is omitted entirely, and the baby is back again on a simple modification.

In the case of babies who have had repeated attacks of sugar fermentation it may be necessary to continue the protein milk over a period of several weeks.

Drugs.—Theoretically it should be of advantage to give by mouth some alkali which would aid in neutralizing the excessive acidity in the intestine. Practically, precipitated chalk seems to help a good deal, and $\frac{1}{4}$ teaspoonful can be given in each bottle of milk that the baby takes.

Results.—The results of proper treatment in acute sugar indigestion are most gratifying, and, treated properly, the condition offers little difficulty. Treated improperly, it is most stubborn, is prone to become more severe, or to turn into a

chronic condition. Repeated attacks of acute sugar indigestion may be responsible for much nutritional damage.

Acute Protein Indigestion.—Acute indigestion from protein is not uncommon. Although it may cause a considerable disturbance for a short time, it is easily remedied, and is not productive of the far-reaching nutritional damage that sometimes follows indigestion of the other food elements.

Cow's milk is rich in casein, which coagulates in the stomach in large tough masses. If too high a percentage of protein is fed, casein indigestion may result. The chief symptom is vomiting of large, tough, irregularly shaped masses of undigested coagulated casein. I have seen these masses so large that they nearly choked the baby when he attempted to vomit them. Casein indigestion is seen in small babies who are taking too high concentrations of whole milk, and in older babies sometimes who have been put on an undiluted milk before they are ready for it. The disturbance is mostly gastric, but often undigested portions of casein find their way into the intestine and appear in the stool as small bean-like lumps, the characteristic "casein curds." These vary from the size of a barley grain to that of a large lima bean, and are of a rather yellowish color. They are tough in consistency, sink in water, and become very hard when placed in formalin. Their appearance is quite characteristic, and when once seen cannot be mistaken for anything else. These casein curds may act as mechanical irritants and may thus cause increased frequency of the movements. There is little if any bacterial action concerned in casein indigestion; the essential nature of the process is that the tough masses of coagulated casein cannot be digested, and thus cause irritation of the gastro-intestinal tract. The German School does not recognize any such thing as protein indigestion, but in our opinion it undoubtedly occurs, especially in babies who are fed on raw milk. The probable reason that German investigators have paid so little attention to protein indigestion is that on the Continent milk is boiled as a routine, which tends to make soft curds in the stomach instead of hard ones. Often in the stools of normal babies who

are apparently not suffering from indigestion a few small casein curds may be seen. In these cases boiling of the milk or slight reduction of the percentage of protein in the food will cause them to disappear.

Treatment.—In accordance with the general principle of withdrawing milk from a vomiting baby, it is well to begin the treatment of an acute protein indigestion by putting the baby on barley-water for twenty-four hours. In most cases the regular diet may then be gradually resumed and curd formation prevented either by reducing the amount of protein, by boiling the milk, or by the addition of lime-water or sodium citrate to the formula. A reduction of the amount of protein and the addition of an alkali is usually the most efficient method. In using lime-water it must be remembered that it must be added in an amount equal at least to 25 per cent. of the milk and cream in the mixture. The practice of adding small amounts of lime-water, which is so commonly followed, does no good whatever. Sodium citrate is probably no more efficient than lime-water, but is far more convenient to use, as its bulk is not so great. Ordinarily 1 grain of this for each ounce of milk and cream in the mixture is sufficient. I am in the habit of giving a prescription containing 20 grains of citrate to the teaspoonful, as follows:

Sodium citrate............. ʒj;
Water..................ad. ℥iv.—M.
S.—One or 2 teaspoonfuls to the day's feeding.

Results should be uniformly good. A very few babies seem to have an idiosyncrasy to protein and need always to be fed small amounts of it. The vast majority of babies, however, have a very good tolerance, and even if this tolerance is overstepped, the resulting disturbance is not difficult to correct.

Acute starch indigestion is occasionally seen in babies from six to ten months old who are first beginning to take cereal, or in younger babies with whom the mistake has been made of giving too large amounts of starch at too early a period. It is almost entirely an intestinal indigestion, and the symptoms are

due partly to bacterial decomposition of the starch, and partly to its action as an undigested foreign body in the digestive tract. The stools are usually increased in number (three to six a day), are of a thin, mushy consistency, of a brownish-olive-green color, and usually of an acid reaction. They often contain small gelatinous masses of undigested starch, and are not smooth in consistency, as a normal stool should be. In some cases, where the starch is simply acting as a foreign body, and no bacterial decomposition has taken place, they are likely to be brownish in color, large in size, and of a hard consistency, which causes constipation. In both groups of cases the stool turns bluish black when an iodin solution is added, and under the microscope large black masses of undigested starch are seen. The treatment consists in omitting starch from the diet for two or three weeks, and then starting in again with smaller amounts. The proper cooking of starch is very important; the starch grains are not broken down if they are not cooked long enough, and if they are not broken down they are likely to be indigestible.

THE CHRONIC INDIGESTIONS

Chronic Fat Indigestion.—Chronic indigestion from fat may result from the fat alone, from fat given with a wrong proportion of the other food elements, or from undigested fat plus the action of bacteria upon it. It is the most common type of chronic indigestion, the most complicated chemically, the most far-reaching in its results as regards severe nutritional disturbance, and the most difficult to treat successfully.

Let us briefly review the digestion and absorption of fat. Fat as it exists in milk is what is known chemically as a neutral fat; that is, a combination of fatty acid and glycerin. A small amount of the fat is split into its component parts in the stomach, but most of the fat digestion is carried on in the intestine. There it is broken down into fatty acid and glycerin by the steapsin of the pancreatic juice. The fatty acid combines with an alkali in the intestine (calcium, magnesium, sodium, or potassium) to form a soap, is emulsified by the bile, and absorbed as a soap.

The calcium and magnesium soaps are relatively insoluble and are absorbed with difficulty, the sodium and potassium soaps are soluble and are absorbed with ease. What fat is going to do in any given intestine depends very largely upon the reaction of the intestinal contents and the rate of peristalsis. If peristalsis is slow and the reaction is alkaline, calcium soap formation results, with constipation and characteristic nutritional disturbance. If fermentative bacteria are acting upon the fat, fatty acids are formed, which stimulate peristalsis and cause loose, acid, curded stools.

If a high fat is fed in combination with a high protein the first picture is likely to result; if in combination with a high sugar and low protein, the second picture may occur. In dealing with fat indigestion, as with any indigestion, macroscopic examination of the stool is of the utmost importance. Microscopic examination is also of much value if interpreted correctly, but may lead the inexperienced infant feeder far astray if he has not a thorough understanding of the subject. Microscopic examination of the stool for fat has been greatly overdone, and has undoubtedly caused much harm. The physician finds fat in considerable amount under the microscope, immediately diagnoses a "fat indigestion," cuts all fat from the diet, and the baby often is unnecessarily underfed as a result. It must be remembered that the normal stool is made up very largely of a residue of unabsorbed fat in the form of soap; furthermore, that young babies always show much more fat in the stools than older children do. The finding of a large amount of fat in the stools of a young baby may be, therefore, of little significance when it would be of considerable import in an older child. It is also of little value to look for fat in very loose stools, as a large amount of unabsorbed fat always comes out in these stools as a result of the increased peristalsis, and does not necessarily mean that the primary disturbance was due to fat; it may have been due to anything which caused a diarrhea. If a baby is having one small stool a day, and it is full of fat under the microscope, it may be of no significance; if he is having two or

more large stools a day which show microscopically an equally large amount of fat, his fat absorption is probably poor, and he is losing more fat in his stool than he should. The amount of fat seen in the stool is of significance only when taken in conjunction with other data, such as gain in weight, general condition, the type of food fed, number and consistency of stools, etc. If a baby were doing well I should care very little whether his stool showed large amounts of fat or not; if he were doing poorly I might pay attention to excessive fat in the stool, or might not, depending entirely upon the circumstances of the case. The amount of fat seen microscopically in the stools of normal babies varies a great deal; some babies always pass stools which contain very small amounts of fat, others have stools which are always full of fat. The method of feeding has a good deal to do with this, as Grover has pointed out. If a baby is fed on a gravity cream and skimmed milk mixture, with a relatively high fat and low protein, most of the fecal residue will, of course, consist of fatty material; if he is fed on a food relatively low in fat and high in protein, the fecal residue will contain relatively less fat on account of the larger amount of protein residue that comes through. If the baby is not gaining, despite an apparently high enough caloric intake, large amounts of fat in the stool are of significance, and it is probable that his trouble is due to fat indigestion. If he is doing well, large amounts may have but little significance. One of the best and at the same time one of the worst things about the Boston methods of infant feeding has been microscopic stool examination for fat. In some cases it is of great value, and by its proper use we can often get a much clearer idea of the case than we could otherwise; but it may be interpreted in quite the wrong way, and often does more harm than good in inexperienced hands.

For practical purposes chronic fat indigestion may be divided into two main types:

Type 1. With constipated stools.

Type 2. With loose stools.

It is common in any given case of chronic fat indigestion to see both these manifestations at different periods, according to the characteristics of the bacterial flora of the intestine at the particular time. The first type is associated with a putrefactive flora, and there is no fermentation of fat or of sugar, whereas the second type has associated with it a fermentative flora, and the symptoms are often due in a large measure to bacterial fermentation of fat, and probably also secondarily of sugar.

Type 1.—This is the condition which has been called by the German school "disturbed metabolic balance" (Bilanzstörung), and is dependent rather upon fat given in improper relationship to the other food elements than to an excess of fat in itself. It is particularly likely to develop in babies who are fed on a food which is relatively high in fat and protein and low in sugar, such as the following formula:

Fat, 3.50; sugar, 5; protein, 2.50.

It is par excellence *the* cow's milk disturbance, and breast milk produces no condition which can be at all compared to it.

The chemistry of the condition is rather complicated, and many conflicting theories have been brought forward. Without going into two much discussion for and against various theories, the following seems the most likely pathogenesis: When a food relatively high in protein and low in sugar is fed an alkaline condition is produced in the intestine. The causes of this are that a large percentage of protein favors the pouring out of a large amount of pancreatic juice, which is strongly alkaline, that the decomposition products of protein are alkaline in character, and that a high calcium is inevitably given whenever a high protein percentage is used, which also favors alkalinity. The relatively small amount of sugar which is given is totally absorbed, and there is none left to support the normal fermentative, sugar-splitting, acid-producing flora of the intestine. The intestinal flora with high protein and low sugar feeding, therefore, becomes putrefactive in type. The higher fatty acids formed from fat splitting in such an intestine as this, where

peristalsis is slow *on account of the lack of fermentation*, have abundant opportunity to combine with the large amount of calcium present to form insoluble calcium soaps, which are best formed in an alkaline medium. These calcium soaps cannot be absorbed, and form large, dry, hard, light colored stools, which contain an excessive amount of fat and of calcium. Thus the baby is deprived of a good many calories which he might be utilizing if his fat absorption were better, and also is continually losing calcium from the body in the form of insoluble calcium soaps. Instead of the normal 20 to 25 per cent., from 30 to 60 per cent. of the ash intake may go out in the stools, and the fat absorption may be as low as 60 or 70 per cent. The fat absorption is never so poor, however, as it is in diarrhea. As we have said before, there are a great many widely varying opinions as to the exact chemistry of this condition, but the one given above is that which is held by most investigators and the one which seems to fit in best with the observed facts.

Symptoms.—The condition is not so likely to be seen in very young babies as it is after the fifth or sixth month. It is slow in its development, and there may be for a considerable period good gains in weight. Then the weight remains stationary, and soon a decline in weight occurs, *despite sufficient caloric intake.* This is an especially important point, and increasing the amount of food is likely to be followed by a further loss and an aggravation of symptoms, rather than by a gain. The baby becomes flabby and pale, and symptoms of rickets may begin to be seen, such as profuse sweating about the head, the development of a rosary, and a too widely open fontanel. Spasmophilia is not at all uncommon in these babies, and may be looked upon as a part of the symptom complex, probably caused by an excessive withdrawal of calcium from the body.

The stools are one of the most important characteristics. They are large and constipated, of a very light grayish-white color, rather foul smelling, and of an alkaline reaction. When treated with glacial acetic acid and soudan III and examined under the microscope the microscopic field seems to be made up

almost entirely of fat globules. The light color of the stools is probably their most important characteristic. This light color is caused by reduction processes in the intestine, as when there is slight putrefaction in the intestine nascent hydrogen is formed, and reduction processes are likely to occur. This reduces bilirubin (the ordinary brownish bile-pigment which gives color to the stools) to hydrobilirubin and urobilinogen, which are colorless.[1]

The more colorless the stools are, the more likely is the process to be a severe one, and Bessau regards this colorless character of the stools as the most important single characteristic of chronic fat indigestion of this type. On account of the continued withdrawal of base from the body a relative acidosis is produced, with an increased ammonia output in the urine, which may smell very ammoniacal.

Diagnosis.—The diagnosis is made by the characteristic symptoms—the fact that loss of weight occurs despite adequate or superadequate caloric intake, the character of the food upon which the baby is being fed, and the nature of the stools. The stools are here very important, and microscopic examination is a valuable aid.

Treatment.—The essential in treatment is to change about the putrefaction processes which are going on in the intestine and to induce mild fermentation. This is accomplished by feeding to the baby an entirely different formula, lower in protein and fat, and higher in carbohydrate. The carbohydrate is raised for two reasons, the first and most important being to promote fermentative, acid processes in the large intestine by supplying it with a chyme containing carbohydrate, the second being the fact that inasmuch as the fat and protein have been considerably reduced, it is necessary to feed a high carbohydrate in order to supply sufficient calories. Carbohydrate is almost always well borne, and one need not ordinarily be afraid of feeding large amounts of it to a constipated baby. It is possible to feed larger amounts when several carbohydrates are

[1] Bessau, Jahrb. f. Kinderheilk., 92, 3d series, vol. 42, 1920.

used than when one alone is given, therefore a combination of carbohydrates should be used. Milk-sugar is the sugar which is most efficient in producing fermentative processes in the large intestine, therefore most of the carbohydrate should be given in this form. It has also been found by experience that better results are obtained when liquid malt extract and starch are used in addition. According to Bessau, the value of malt extract lies in the fact that it is partly caramelized. It is hardly ever necessary to completely omit the fat in dealing with this type of indigestion. It is sufficient to remodel the type of food, and to offer one in which the arrangement of the food elements is different. Reduction of the protein is of just as much importance as reduction of the fat. A great many times physicians who are unfamiliar with the chemistry of the condition remove all the fat without doing anything else. This gives too low a caloric value to the diet, does not correct the underlying disturbance, and thus fails to give good results. In cases where the process has been going on for so long that the fat tolerance is very low, the baby may be able to take no fat at all. In these cases total omission of the fat over a considerable period of time, with as great an increase as possible in the protein and carbohydrate, may be necessary.

Example.—Let us suppose a six months' old baby was being fed on fat 3.50, dextrimaltose 5, protein 2.50. He develops typical chronic fat indigestion, with dry, colorless stools.

Treatment.—The protein should be cut to 1.50 per cent., the fat to 2, and the carbohydrate first raised to *lactose 5*, *maltose 1*, barley starch 0.75. If this is well borne, it may be gradually raised in a good many cases to a total of 8 or 10 per cent. Usually not more than 1 per cent. of maltose should be used, as more than this has a tendency to cause diarrhea. The addition of lactose should also be done cautiously, as it is of course not desirable to promote excessive fermentative processes. With this feeding, the stools soon become soft, acid, the constipation is overcome, and the baby begins to gain in weight. Keller's malt soup has been used extensively, with excellent results. It

is essentially a low fat and low protein food, containing a high polycarbohydrate (see Chapter IX).

Type 2.—In this type of chronic fat indigestion the trouble results either from a gross overfeeding with fat, or from an inability of the baby to digest normal amounts of fat. It is often combined with a sugar intolerance. The stools are usually loose in character, of a yellowish or of a yellowish-green color, acid in reaction,[1] with many whitish undigested fat curds. They may vary in number from three to six a day, and if they are strongly enough acid excoriation of the buttocks may result. Vomiting is common in this type of indigestion, particularly in those cases where the baby is being grossly overfed with fat. The stools may be very oily in character, and when placed on a piece of paper may leave a transparent stain in the same way that a piece of putty would. Microscopically they contain a great deal of neutral fat which has been entirely unsplit. In most cases of fat indigestion, however, the fat is usually split into fatty acid and glycerin efficiently enough, but is not absorbed. Fat indigestion of Type 2 differs considerably from Type 1. In the latter the intestine reaction is alkaline, and the trouble is caused, as we have seen, by fat in improper combination, rather than by the fat itself alone. In the former the fat alone is usually responsible, the intestinal contents are acid in character, and irritate the mucosa, which results in loose movements. There may be associated considerable abnormal bacterial fermentation of fat, and not infrequently of sugar as well. These babies rapidly lose appetite, weight, and strength, and after the condition has persisted for some time an extreme fat intolerance may develop, and a condition of "marasmus" may result. In either type of case the tolerance for fat is low, but is more likely to be lower in the second type than in the first. After a fat indigestion of either type has been continued for a long time the same end-result is reached, however—an extreme intolerance for fat, no matter in what combination it may be given.

Treatment.—A complete or nearly complete withdrawal of

[1] In some cases the stools may be alkaline.

the fat from the diet is usually necessary. This necessitates an increase of the other food elements. The protein, in particular, should be raised as high as the baby can stand, and babies of this type often do well on concentrated boiled skimmed milk mixtures. The proper management of the sugar is of great importance; it is desirable to give as much sugar as possible without producing sugar fermentation. This is sometimes difficult, as the sugar tolerance is often poor, and there may be associated with the fat incapacity a sugar indigestion. These cases should be fed, temporarily, at any rate, on one of the protein milk preparations already discussed under Acute Sugar Indigestion. The best sugar to use is dextrimaltose, as it ferments less easily than the other sugars, and the baby can, therefore, take more of it without developing sugar fermentation than he could of lactose. Starch can also be very advantageously added to the diet, even with babies who are under the age when one would ordinarily begin starch. It is well known that even very young babies can digest a little starch, and 0.75 per cent. of barley starch may be tried in the formula in feeding a baby with fat indigestion who is over two or three months old. If it does not agree, it is easy enough to discontinue it. Dried milk has a real place in the treatment of this type of case; it is very low in fat, relatively low in sugar, and high in protein in an easily assimilable form, and certain cases of chronic fat indigestion do remarkably well on it. When a level tablespoonful of Dryco Brand dried milk is added to 8 ounces of water the percentages are: fat 1.5, sugar 5.5, protein 4.2. In order to cover the baby's theoretic caloric needs it is necessary to use 3 level tablespoons of dried milk per day for each pound of the body weight (Dennett), Theoretic caloric requirements are, however, likely to be misleading in any undernourished baby, as thin babies usually need more than the theoretic requirement. Some cases do well on lactic acid milk mixtures to which starch has been added, especially if the sugar tolerance is low, and there is a tendency to sugar fermentation. The feeding of homogenized olive oil mixtures is

remarkably successful occasionally, and is always worth a trial if other means fail. The difficulty in the use of homogenized olive oil has been that it is not obtainable outside of large cities where there are milk laboratories. The milk laboratories are now, however, putting up concentrated homogenized olive oil in mucilage of acacia which may be shipped to a distance, and which will keep indefinitely. This preparation is simply mixed with fat-free milk in any desired strength in the same way that ordinary cream would be.

Chronic sugar indigestion is common. Its chief characteristic is the passage of loose, frothy, green, acid bowel movements, usually containing a good many soft white curds and often mucus. In some cases regurgitation of thin, watery material may also occur without diarrhea, but usually the intestinal symptoms are by far the more prominent. The stools usually vary from four to six or seven a day, and may be very loose or in mild cases merely somewhat spongy or frothy. The buttocks soon become much excoriated from the excessively acid stools, and loss of weight is rapid, so much so that if the condition persists the baby finally gets into a condition of extreme malnutrition. The essential pathology is a fermentation of unabsorbed sugar in the intestine. This may be due to continued overfeeding with sugar, or, more likely, to an inability of the baby to digest normal amounts. The intestinal contents become strongly acid, and stay so; while the loose movements that result prevent the proper absorption of all the food elements, especially salts of the alkalies, which partly accounts for the steady loss of weight. There is also, besides the sugar fermentation, probably in most cases a certain amount of secondary fat fermentation, which aggravates the picture. Protein is well digested, and any undigested casein in the stools is probably due to the rapid peristalsis rather than to any primary indigestion of protein.

Treatment.—The first essential in treatment is to stop the excessive fermentation that is going on, and to secure normal stools. This must be done before any gain in weight can take

place. In mild cases, where the baby is having only a few stools a day, and these show only slight evidences of fermentation, it may be sufficient to simply cut down the amount of sugar or to change the kind of sugar. Often a change from lactose to dextrimaltose is efficient, but occasionally instead of making the condition better, this change may make it worse. In the cases with regurgitation, without intestinal symptoms, reduction of the percentage of sugar is usually sufficient. In any case of ordinary severity, that is, where there are several greenish, sour, curded stools a day, it is always best to begin immediately with one of the low sugar, high protein preparations (original "eiweissmilch," precipitated casein milk, skimmed milk dilutions with powdered casein, lactic acid milk dilutions), and it is a waste of time to try to treat the condition in any other way. With low sugar and high protein feeding in most cases the stools will become smooth and formed in a few days. When this stage is reached, small amounts of sugar may be gradually added, and it is often possible to give considerably more sugar in a protein milk combination than it is in an ordinary milk formula.

After the baby has been fed in this way for a few weeks it is usually possible to gradually go back to an ordinary formula, It is best to start with a simple gravity cream and skimmed milk or whole milk formula, which contains not more than 4 or 5 per cent. of sugar. One feeding of this is substituted for a protein milk feeding, then, if no bad results occur, the protein milk feedings are diminished, and the others increased, until finally the entire day's supply consists of the ordinary formula. If the stools remain smooth and well digested, sugar may be added up to 6 or 7 per cent., but in many cases it is necessary to continue on a rather low sugar over a considerable period of time. Dry milk or lactic acid milk mixtures also work very well in some cases.

Chronic Starch Indigestion.—This is usually seen in older children, and will be discussed in another chapter.

Marasmus (Infantile Atrophy, Athrepsia, Decomposition). —*Definition.*—An extreme degree of malnutrition, dependent

upon prolonged indigestion or underfeeding. The end-result of long-continued indigestion, whether due to fat, starch, or sugar. It is of such a striking appearance, so well defined clinically, and the nutritional damage is so extensive, that it seems best to classify it as an end-result, and not to speak of it as a "chronic indigestion."

Occurrence.—Marasmus is not usually seen before the second or third month; after this it may be seen at any time. "Chronic intestinal indigestion" or "intestinal infantilism" is its equivalent in older children. It is not nearly so common as formerly, because artificial feeding is so much more satisfactory than it used to be. It is seen especially among the poor, and represents one of the most common groups of cases treated in any hospital devoted to infants. It is not at all common in well-to-do private practice.

Etiology and Pathogenesis.—If a baby has a severe chronic indigestion which extends over a long period of time, he does not absorb sufficient calories to cover his nutritional needs. The body fat is, therefore, drawn upon and used as fuel. When this is exhausted the body protein may be drawn upon to a certain extent. There is a continued loss of salts from the body in the stools, particularly if diarrhea is present, and there may be a negative nitrogen balance. The baby finally reaches a condition of "metabolic bankruptcy," as Finkelstein has said. Thus certain of the body cells disintegrate, and all the vital functions, especially that of digestion, become weakened as the condition progresses. There is, as Marriott[1] has shown, an actual atrophy of the blood, due to the using up of the blood protein, which "leads to a diminished volume, and this, in its turn, to a diminished volume flow[2] of the blood." This results in diminished oxidation of the tissues, and poor nutrition of every part of the body. "It is not surprising that the intestinal tract and the digestive glands supplied by an atrophied,

[1] Marriott, Notes on Infant Nutrition, 1920.

[2] The amount of blood passing through a given part of the body in a unit of time.

poorly circulating blood should be functionally inefficient, with the result that digestion and absorption are poor."[1] Various observers have reported a deficiency of the digestive ferments as a cause of marasmus, but it is probable that this is a result of the condition rather than its cause. The fat-splitting ferment of the pancreas is particularly likely to be deficient, and the hydrochloric acid of the stomach may also be considerably diminished.

The pathologic lesions at autopsy are insignificant, and, indeed, there are no distinctive or characteristic lesions. Tuberculosis, syphilis, congenital atelectasis, and many other diseases may produce very much the same picture. The type of case discussed here is, however, to quote Dr. Holt, "a vice of nutrition only."

Almost all observers have reported a diminished fat absorption, although in most cases the fat is split as well as normally. The nitrogen and salt balances are likely to be negative when weight is being lost, but during periods of stationary weight or of increasing weight are positive. There may be a secondary relative acidosis caused by withdrawal of base from the body and the suboxidation brought about by the diminished volume flow of the blood.

Clinical History.—A baby of six months is brought, who weighs 7 pounds. He is little more than skin and bones. He was breast fed for a few weeks and then nursing was discontinued because the mother's milk left her, or because she or her doctor "though it was too weak." The baby was then started on a top milk mixture containing a large amount of fat, or on condensed milk, or on a proprietary food formula. He did well for a while, and then began to have loose, undigested stools, and to lose weight. He was then tried on one thing after another, with equally bad results, and with an increasing intolerance for food of any sort. He may have vomited considerably; the stools may have been constipated, of the "soap stool" type, if he has been fed on a high fat, or diarrheal and acid if he has

[1] Marriott, loc. cit.

had an intolerance for sugar. There has been a progressive loss of weight, until finally an extreme stage of malnutrition is reached.

Clinical Appearance.—The most striking thing is the extreme emaciation. The baby may be little more than a skeleton covered with skin and a little flabby muscle tissue. The face is very sharp and weazened, giving the characteristic "little old man" appearance. The flesh is extremely soft and flabby, and the skin hangs in inelastic loose folds. The arms and legs are like pipestems and the hands like the claws of a bird. There is practically always a secondary anemia, sometimes of a severe degree, and often a peculiar grayish color of the skin. The heart sounds are feeble and the pulse usually slow. The abdomen is usually distended and the coils of the intestines may be seen through its thin walls, or if diarrhea has been profuse, and the baby is "dried out," it may be much sunken. The hands and feet are cold and may be cyanotic. The temperature is likely to be subnormal, and may sink as low as 94° or 95° F. The face has an anxious expression, but the mentality is usually alert, and the bright eyes assume an unusual prominence in the shrunken face. The child seems continuously hungry, and is very likely to suck its hands. Food is usually taken voraciously, but occasionally the baby will take so little that tube feeding has to be resorted to.

The stools may be of almost any variety. For a while they may be constipated, alkaline, and somewhat foul, with a large insoluble soap residue, especially if the baby is fed on mixtures containing any but a very small quantity of fat. Diarrhea occurs on the slightest provocation if the food tolerance is overstepped, and it is during the diarrheal periods that large and rapid losses of weight may occur. The diarrheal stools may be strongly acid in character and green in color, or, again, may be alkaline and brown, with a foul odor. There may be occasionally very rapid gains in weight, which are caused by the development of edema, and rapid gains should, therefore, always be regarded somewhat skeptically. Furunculosis is

common and often very difficult to get rid of. In a hospital ward one of the greatest problems is to prevent the development of upper respiratory infection, and otitis media, bronchitis, and bronchopneumonia are very common. It is these upper respiratory infections which largely account for the high mortality in marasmic infants.

If excessive intestinal fermentation occurs there may be a rapid development of toxic symptoms, in which case the baby becomes very apathetic and drowsy, and we have added to the condition of marasmus one of intoxication.

Treatment is most difficult, and taxes to the utmost the resources of the art of infant feeding.

In any severe case of marasmus a wet-nurse should be secured if possible, and in many cases success will not follow without one. In most of the ordinary "feeding cases" encountered wet-nurses are not now-a-days necessary, on account of the fact that our knowledge of artificial feeding is so much better than it was in years gone by. But in marasmus the nutritional damage has proceeded so far that nothing can serve so well as human milk.

Wet-nurses are a problem. In the present day so many people live in small apartments that there is not room in the household for a wet-nurse, to say nothing of her baby, which has to go with her. Wet-nurses and their babies do not fit well in small households. Still, if it is a question of saving a life, arrangements may be made, and if the situation is carefully explained to the family, they are willing to put up with the oftentimes severe inconvenience and heavy expense. In large households where a wet-nurse could be easily cared for and paid marasmus does not occur, and it is the poor, who are unable to care for wet-nurses, who need them most. It is often possible for the mother to find some nearby friend with a nursing baby who will come in two or three times a day and give a nursing, or who will pump her breasts and send a few ounces of milk a day. This is decidedly worth while, as even a small amount of breast milk may serve to swing the balance in the baby's favor.

Even with breast milk considerable caution must be used, and the baby should never be put to the breast for a full nursing in the beginning. For the first few days not more than 10 or 12 ounces a day should be allowed, making up the balance with water. It is usually best to let the baby take only the first part of the nursing (the "fore-milk"), so that he will not get the "strippings" or last part of the milk, which is rich in fat. Sometimes the fat tolerance, even for breast-milk fat, is so poor that it is necessary to pump the breast milk, to "set" it for six hours or more, and then to skim the cream off, giving the baby a nearly fat-free milk. Even with breast feeding good results do not always occur at once. The baby must be underfed at first, as if enough food is given to supply his caloric needs it is likely to upset him, so gain in weight cannot be expected for some time. Breast feeding should not be given up, therefore, simply because the baby does not gain for a week or two, or because the breast milk does not seem to "agree with him." As the general condition begins to improve, and his food tolerance increases, he may be allowed to nurse longer, until finally he is taking the full nursing. When breast feeding is discontinued it should not be done abruptly, but one or two feedings of a rather weak modification should be substituted for an equal number of breast feedings, until the baby is gradually fed entirely on the bottle.

Artificial Feeding.—Reduced to its simplest terms, we are confronted with the following problem:

We have a baby whose caloric needs are much higher than those of a normal baby of the same weight, *but whose food tolerance is so low that it is not possible to meet these caloric needs and to bring about a gain in weight without producing a severe digestive upset.* The slightest overstepping of the food tolerance may result in a severe diarrhea with a marked loss in weight. The general principle of treatment is, then, to begin with a very weak food, entirely irrespective of caloric requirements, and to gradually increase it, not expecting a gain in weight for some time.

If the stools are loose and undigested the first essential, the first stage in the treatment, the "reparation" stage, so-called, is to stop the diarrhea, and to feed such a food as will cause the movements to become smooth and infrequent. No baby can go ahead, and will almost certainly go backward, if diarrhea is present. The diarrhea cannot, however, be treated in just the same way that it might be in a more normal baby, as marasmic infants bear starvation very poorly. It is never well to starve them even to clear up a diarrhea.

The following three general principles hold for most cases:

1. Fat is handled very poorly, and any formula that is used, except perhaps protein milk, should contain very little fat.

2. It is desirable to get as much sugar into the baby as possible. If the sugar tolerance is good, as it is in many cases, the treatment is vastly simplified, as it is possible by the use of a high percentage of sugar to furnish many extra calories. The sugar tolerance may be poor, however.

3. Protein is handled better than either of the other food elements, and it is upon mixtures high in protein that we usually rely.

Details.—In a case with loose movements, protein milk, dried milk, or boiled skimmed milk mixtures are the most reliable preparations to begin with. To the first about 3 per cent. of dextrimaltose should be added, with the last two no sugar should be used in the beginning.

The feedings should be very small to begin with and at frequent intervals, usually every two hours. In an average case not more than 1 ounce of protein milk should be used at a feeding, the balance of the feeding being made up with water in amounts to correspond with the age and size of the child, in order to supply the fluid needs of the body. As the stools improve the intervals may be lengthened to 2½ or three hours, and the amount at each feeding increased. When the stools have become smooth and salve-like, carbohydrate, in the form of dextrimaltose, may be gradually added up to the limit of tolerance.

If dried milk is used it is well to begin with not more than one-third strength, that is, about 2½ level tablespoons of Dryco dried milk to 8 ounces of water. This gives a very weak food, containing practically no fat, and a relatively high percentage of protein in an easily assimilable form. As the stools improve this can be very gradually increased up to the full strength, that is, 8 level tablespoons to 8 ounces of water, which gives 1.5 per cent fat, 5.5 per cent. sugar, 4.2 per cent. protein. If the stools remain smooth and apparently well digested, and the baby is not gaining weight, more sugar may be added, up to the limit of sugar tolerance. If skimmed milk is used, the initial formula should be usually one-half milk, one-half water or barley-water, giving percentages of fat 0, sugar 2.25, protein 1.60. It should always be boiled in order to insure a soft casein curd, and it is often possible to give high concentrations of skimmed milk in this form. In some cases it is possible after a while to use undiluted boiled skimmed milk, and often considerable sugar may be added without symptoms of intolerance. It is always advisable to use a centrifuged fat-free milk if possible, as with the ordinary methods of skimming there is always some fat left, which is likely not to be tolerated.

In cases with constipated stools it is best to begin with ordinary milk mixtures (boiled) containing no fat, a fairly high carbohydrate (6 to 7 per cent.), and a moderate protein percentage (1.50 per cent.). If the sugar tolerance is good, as it well may be in constipated cases, with alkaline stools, it may be possible to increase the carbohydrate to 8 or 10 per cent., or even more, provided no fat is given. Keller's malt soup, containing 12 per cent. of carbohydrate in various forms (see Chapter IX), works very well in some cases. Fat can be gradually added, ½ per cent. at a time, as the baby begins to get stronger and generally better. The stools should be examined microscopically every few days, and if large amounts of fat are coming through it is well to reduce the amount of fat in the food even if there are no symptoms, as a fat "blow up" with diarrhea and loss of weight may occur suddenly and without warning.

Condensed milk is sometimes of value to tide over a difficult stage, especially when the stomach is intolerant. Condensed milk is a very weak food, very high in carbohydrate, and low in fat and protein, and is not suitable as a permanent food, but is so easily assimilable that in a few cases it will be kept down when nothing else will. In cases with diarrhea it should not be used, as it is too high in carbohydrate. Fat-free lactic acid milk and corn syrup mixtures, as advocated by Marriott, are often very successful. If fat-free lactic acid milk is diluted one-half with water the percentages are fat 0, sugar 2, protein 1.75. Corn syrup may be added to this mixture, sometimes in large amounts, and it may be possible to introduce many sugar calories in this form without causing diarrhea. If 45 c.c. of corn syrup and 55 c.c. of water are mixed, the resulting 100 c.c. of mixture contains about 50 grams of carbohydrate, consisting of maltose, dextrins, and dextrose; 10 c.c. of this, added to a 4-ounce feeding, increases the sugar percentage a little over 4 per cent. In some cases Marriott[1] was able to use as much as 12 or 14 per cent. of carbohydrate in this medium, with very good results, and undoubtedly it is often possible to use a higher carbohydrate in a protein milk or lactic acid milk mixture than in any other way. I have had personally very little experience with this method of feeding, but it would seem to be a very valuable addition to our armamentarium in treating marasmic babies.

Homogenized olive oil mixtures are sometimes useful, and it may be possible to use 2 or 3 per cent. of fat in this form when no butter fat can be tolerated.

Warmth.—The marasmic baby has practically no fat tissue to prevent the loss of heat from his body; his surface area is large in proportion to his mass; therefore he loses heat readily, and may be put into the same category as the premature in this respect. It is absolutely essential to keep him warm, and it may be necessary in very bad cases to wrap the child in a jacket in the same way that a premature would be cared for.

[1] Loc. cit.

The temperature is just as important to watch as the weight, and if it is subnormal, hot-water bottles should be kept continually in the bed. Dr. W. W. Howell, of the Infant's Hospital, has some rather remarkable charts, showing the effect of the temperature at which the marasmic baby is kept, on the gain in weight. Many times he has moved marasmic babies back and forth from the regular ward of the hospital to the hot room (kept at 80° F.), and his charts show without question that gain in weight is much more rapid and more certain in most cases when the temperature is kept between 75° and 80° F. than at the ordinary ward figure. These facts should always be borne in mind when dealing with a marasmic baby, and a brief chilling may mean all the difference between life and death.

Drugs are of secondary importance, but may help sometimes in tiding over difficult periods.

The artificial digestants are of little value, and are not used by most men who are familiar with marasmus. Precipitated chalk in $\frac{1}{4}$ teaspoonful doses to each feeding may help to control a diarrhea if the stools are excessively acid. The stimulants that have been used are brandy, adrenalin, caffein, and camphor. Of these, brandy is probably the best, and small doses of it may be sometimes useful to tide over a critical stage. The effect of adrenalin is powerful in collapse, but is very transitory. Caffein and camphor may be of use if the heart action is weak. As a general thing drug stimulation is of secondary importance; what a marasmic baby needs is to have its body cells absorb *food and fluid.*

Subcutaneous and *intravenous injections* of normal saline or of glucose may accomplish a great deal in some cases. For a discussion of the technic and indications see the chapter on Diarrhea.

Course.—The baby will not begin to gain weight until his caloric needs are well covered, which in many cases will not be for some time. If he is not vomiting, if his stools are good, if his general condition is better, and he is not *losing* weight, it is well to be satisfied for a time before increasing the diet. As we have said before, theoretic caloric requirements are often

of little value as a practical guide for feeding, but as a general rule marasmic babies will not begin to gain until they are getting at least 60 calories per pound, and often need more than this. If the sugar tolerance is good, it is often possible to feed a high caloric diet without much risk of an upset. Relapses almost always occur, brought about sometimes by overfeeding, sometimes from the influence of intercurrent infections. During a relapse the stools become loose and frequent, the color of the baby bad, the temperature either subnormal or elevated, and the weight sinks very rapidly. In some cases there may be evidences of extreme intoxication, as evidenced by somnolence, hyperpnea, and collapse. During periods of diarrhea it is never well to starve the baby, as we might do with a normal baby, as marasmic cases bear starvation very poorly, and are likely to die from it. The food should, however, be somewhat reduced in strength, and if a high sugar has been used, and the stools are acid in character, it is best to shift to a low sugar and relatively high protein; if a high protein feeding has been used, one would shift to a low protein and relatively high sugar.

It is of great importance during periods of diarrhea or during times when the baby is not eating well to keep up the fluid intake, and for this purpose normal saline should be given subcutaneously or glucose solutions intravenously. One of the worst things that can happen to a marasmic baby is to get "dried out," and the fluid intake should always be regulated as carefully as the fat, carbohydrate, and protein. Even under the best conditions treatment is long drawn out, and many discouragements will have to be met before the baby goes ahead steadily. In many cases no food, no matter what is tried, seems to be able to bring about an increase in weight; then often, after several weeks of careful dieting, the baby will shoot ahead all of a sudden, and continue to do well, upon some food which before failed to cause him to gain. It would seem as though a period of freedom from intestinal irritation were necessary before the intestine is able to absorb enough food in order to bring about an increase of weight. As a general thing

marasmic babies do better at home than in a hospital, provided the home is a good one, largely because the risk of infection is much less, and they are likely to get more individual attention.

Prognosis.—Doubtful always. The baby may be apparently doing well, then may pick up some seemingly trivial naso-pharyngeal infection, develop a bronchitis or a bronchopneumonia, and die from it. Or sudden collapse and death may occur without apparent reason. In the very worst cases the chances of recovery with artificial feeding are always bad, and these cases must have breast milk or die. The average case ought to recover with intelligent artificial feeding, although it may be a good many weeks before much weight is gained. When once the baby starts to gain, progress may be rapid, and a case of this sort that is doing well is indeed a satisfaction. The younger the baby, the worse the prognosis, as a general thing. The cases due to underfeeding and neglect are likely to respond better than those due to long-continued indigestion. When once the nutritional damage has been repaired, and the child is of normal weight for its age, the chances are that he will be as healthy as any other child.

A FEW GENERAL SUGGESTIONS FOR DIFFICULT FEEDING CASES

1. A careful history is of great importance; it shows what has been well borne in the past and what has not, and gives valuable suggestions as to what to avoid. The last man who gets one of the difficult feeding cases which have been the rounds of several pediatrists is the one who is most likely to succeed with it, as he profits by the experience of his brother practitioners.

2. It is always a good idea on beginning with a difficult case to tell the mother that "Rome was not built in a day" and that a malnourished baby cannot be made fat over night—but that if she will be patient, good results are sure to be secured in the long run.

3. In any case with undigested, loose movements, the movements must be made smooth and of normal consistency before

satisfactory progress as to weight can be expected. This is the first stage in the treatment of most cases.

4. It is not well to be too eager for rapid and large gains in weight. Be satisfied with a few ounces a week for a few weeks if the baby is eating well, feeling well, and having good stools.

5. It is a mistake to change formulæ too quickly. Give the baby a good try-out of several days on a formula before deciding that it does not agree with him.

6. If more than one element is increased at a time it is very difficult to tell what has upset the baby, if upset occurs.

7. Theoretic caloric requirements are of very little practical value—feed the baby all he will stand, irrespective of calories.

8. Use as high a sugar as is possible without causing fermentation. If the stools are not loose the baby can probably take a great deal of it without being upset, and the more sugar he can absorb, the more weight he will gain.

9. Never forget that the high protein, low sugar principle (protein milk, etc.) is the most efficient way of stopping abnormal intestinal fermentation.

10. Malt sugar preparations are by no means always a cure for sugar troubles. In some babies they ferment as easily as lactose.

11. Loss of appetite is one of the most common symptoms of beginning fat indigestion.

12. Remember that starch is not used as much as it should be in difficult feeding cases. Some babies improve remarkably as soon as a little starch is added to the formula.

13. Have always a definite plan of campaign in every case, *and stick to it.*

14. The proprietary foods can contain nothing that your own milk modifications cannot contain.

15. The more one knows about the chemistry of digestion and its abnormalities, the processes that are going on in the bowel, the more likely is he to get good results. One would not consider that he had an adequate idea of a disease such as pneumonia without knowing something of its pathology. It is

just as necessary to have a knowledge of digestive pathology in order to feed infants successfully. The reason why so many practitioners get poor results in infant feeding is that they have no knowledge whatever of the processes that are going on inside the baby; they try this and that formula or preparation, without knowing *why*. Ask yourself *why* for every formula you use and every change you make.

CHAPTER XI

IDIOSYNCRASY TO COW'S MILK

Most babies who are supposed by the mother to have an idiosyncrasy to cow's milk are not suffering from any specific idiosyncrasy, but their symptoms are caused by improper modifications of milk, and can usually be corrected with proper feeding. There are cases, however, not so very uncommon, of true anaphylactic idiosyncrasy to cow's milk protein, and in some instances ingestion of even a few drops of milk may bring about alarming symptoms. Within a few minutes the lips, tongue, and buccal mucous membrane swell, and there may be symptoms of collapse. These symptoms usually disappear in an hour or two, and are likely to be followed by urticaria, which may last about twenty-four hours.[1] In other cases, the idiosyncrasy may be manifested by asthmatic attacks, following soon after the ingestion of milk, or by eczema. Again, there may be vomiting and drowsiness, which may not come on for two or three hours after the milk has been taken, as in Park's case,[2] or severe sudden diarrhea. There is almost always some skin manifestation, such as urticaria or angioneurotic edema, and in 2 cases of milk idiosyncrasy that I have had recently in my own practice, one was manifested only by a very extensive skin eruption resembling erythema multiforme, the other by extreme swelling of the lips and cheeks. In mild cases there may be little systemic disturbance, and the manifestations may be confined entirely to the skin. In the severe cases the symptoms may be very alarming and may threaten life, although I have been able to find no report of any case which has died. The idiosyn-

[1] Schloss, Amer. Jour. Dis. Chil., vol. 19, 1920.

[2] Amer. Jour. Dis. Chil., vol. 19, 1920.

crasy may exist from birth or may be acquired. Park's case was only six weeks old, and had never received cow's milk before, as far as was known. The condition is most likely to be seen in somewhat older babies when they are weaned, the symptoms usually making their appearance the first time cow's milk is taken.

Diagnosis.—The diagnosis is simple and depends upon cause and effect, the cause being the taking of cow's milk, the effect, the symptoms which soon follow. In most cases the symptoms follow so soon upon the taking of milk that the mother makes the diagnosis. As we have said, the trouble has to do only with the protein of the milk, and the sensitization may be either to casein or to lactalbumin, most commonly to the latter. In only 2 out of Schloss's 14 cases of milk idiosyncrasy did casein cause a skin reaction, and then to a much less marked degree than lactalbumin. It is important to determine to which of these proteins the anaphylactic phenomena are due, as treatment is sometimes planned accordingly. In a great many cases the skin tests will indicate this. These are very simple to do, and purified powdered proteins from all sorts of foods are on the market.[1] Three scratches about ½ inch long are made with a needle into the skin of the back,[2] and a small quantity of the powdered lactalbumin and casein placed on two of the scratches, the third being left for a control. Then a drop of N/10 sodium hydrate is added from a medicine-dropper and is mixed with the protein. If the test is negative there is no difference between the control and the scratches to which protein has been added. If the test is positive, in about five minutes an urticarial wheal appears, which is surrounded by a red areola. It has been said that a wheal to be positive must measure at least ½ cm., and that all reactions of this size should be considered positive. It is probably better, however, to use the control as a standard, and if the protein being tested gives a wheal which is noticeably

[1] Arlington Chemical Co., Yonkers, N. Y.

[2] The arm is the place ordinarily used, but we have found at the Children's Hospital that in dealing with babies the back is more convenient.

larger than that caused by the control scratch, it is better to call it positive, no matter how large or how small it may be.

A negative skin test is not at all reliable, and a good many cases of milk idiosyncrasy will show negative tests both to casein and to lactalbumin, as after an attack of anaphylaxis there may be often a period of anti-anaphylaxis, when the patient is not sensitized, which may last for several days or weeks. Schloss[1] has reported 5 cases of undoubted idiosyncrasy to cow's milk, with persistently negative skin tests.

Treatment.—Certain cases may be able to take without disturbance dried milk, evaporated milk, or milk which has been vigorously boiled. This difference is probably due to some change produced in the protein by heating. It is worth while in cases of moderate severity to try one or all of these methods; but if the idiosyncrasy still persists the method of treatment is to feed the infant upon goat's milk, as in practically all these cases there is no idiosyncrasy to goat casein or lactalbumin. If the baby is not too old, and it is easier to get a wet-nurse than a goat, this method of feeding is satisfactory. If the family lives in the country a goat can be easily obtained and kept; if they live in the city this is usually out of the question, but often arrangements may be made with a milkman to get a goat, and deliver the milk daily.

Another more satisfactory and simple way of using goat's milk is in the evaporated form, and a very satisfactory evaporated goat's milk may be obtained, which is often truly a godsend to a family living in the city. (For details of evaporated goat's milk see Chapter VIII.) I fed one baby with severe cow's milk idiosyncrasy on evaporated goat's milk for over six months, with very good results. In severe cases goat's milk or human milk is necessary, but in mild cases it is often possible, provided it is known whether the offending substance is lactalbumin or casein, to make up a milk modification containing so little of it that no symptoms result. If the idiosyncrasy is for lactalbumin a precipitated casein mixture may be employed, and if a heavy

[1] Loc. cit.

cream is used the mixture will contain very little lactalbumin.[1] If the idiosyncrasy is for casein, a whey mixture is indicated. It is usually best, however, to turn to goat's milk, as these mixtures may not be suitable for administration over a long period of time. They may do, however, to tide over while the goat is being found or while the evaporated milk is being obtained. It is well in all these cases to begin solid food as early as possible, and cereals, spinach, and beef juice may be started in small amounts at the seventh or eighth month. Olive oil may also be of value in some cases.

Desensitization.—A good many cases become desensitized spontaneously, and may be able after a few months of feeding with the goat milk to take cow's milk with impunity. Or they may be desensitized by administering very small and gradually increasing amounts of cow's milk. It may be necessary in severe cases to use very small amounts of cow's milk, sometimes as little as $\frac{1}{20}$ drop of milk three times a day to begin with (Schloss). It is usually safe to start with a drop three times a day, and to increase this dosage day by day if no symptoms occur. The results are likely to be good, and desensitization can usually be accomplished in a few months. Milk idiosyncrasy is not likely to persist into childhood, although some children who have had a milk idiosyncrasy are never very fond of milk, and cannot be made to take much of it.

[1] Or the milk may be boiled and the scum on the surface, which consists largely of coagulated lactalbumin, removed by skimming.

CHAPTER XII

THE DIARRHEAL DISEASES[1]

The diarrheal diseases, often spoken of collectively as "summer diarrhea," undoubtedly kill more babies than any other one cause. These diseases are largely preventable, and in most cases respond to proper therapy, whereas many improperly treated cases die, often on account of poor treatment. It is, therefore, essential for all physicians dealing with children to have as clear an idea as possible of these conditions. The diarrheal diseases have always interested pediatrists, and in going over the literature I was so struck by the confusion that exists in the nomenclature, classification and treatment, and by the opposing views held by many authorities, that I have purposely left out all references, arguments, and contradictory opinions from this chapter, and have written in a dogmatic manner, which is probably not justified, but which will undoubtedly give to the reader a clearer conception of the diarrheal diseases than would otherwise be the case. The diarrheal diseases occur chiefly in the summer and bear a definite relationship to hot weather. In the South they begin to appear about the middle of May; in Boston, usually not until the first part of July. They are especially common during muggy weather. They attack chiefly bottle-fed infants up to two years of age, largely of the poorer class.

Any diarrhea is caused by increased intestinal peristalsis. This increased peristalsis is caused by some irritant acting on the intestinal mucous membrane, and it is best to classify diarrheal conditions according to the type of irritant that is causing

[1] Much of this chapter appeared in the Journal of the American Medical Association for June 7, 1919, and I am indebted to the editors for permission to use it again.

the trouble. Broadly speaking, the diarrheal diseases of infancy may be divided into three groups:

1. *Mechanical diarrhea,* due to mechanical irritation.
2. *Fermentative diarrhea,* due to chemical irritation.
3. *Infectious diarrhea,* due to bacterial irritation.

In the first group the irritation is mechanical, and is caused by undigested pieces of food, or by such things as unripe fruit, seeds, or skins. In the second group the trouble is caused by irritating products from bacterial fermentation or putrefaction of food in the intestine, brought about in several different ways, as we shall see later. There is no infection by bacteria of the intestinal mucous membrane in this condition; it is the intestinal contents which are infected. In the third group there is actual invasion of the intestinal mucosa by bacteria, with catarrhal inflammation, or often actual ulceration.

This is an exceedingly simple and in most cases a satisfactory classification. It must be remembered, however, that the lines between the three groups are not always hard and fast, for these reasons:

1. With any diarrhea there is always some fermentation, even if the primary cause be infectious or mechanical.

2. In infectious diarrhea in most cases the trouble is caused by a direct infection per os of the previously healthy intestinal mucosa, with virulent pathogenic bacteria (dysentery, streptococcus) introduced from without. This is not, however, always the case, and if the mucosa of the bowel is first injured or irritated by chemical or mechanical agencies, bacteria (colon bacilli, gas bacilli, dysentery), normally living a more or less saprophytic existence in the intestine, may be able to get a foothold in the irritated places, and thus infect the previously irritated mucosa, when they would be powerless against it if it were uninjured. Thus it is frequent for mechanical or chemical agencies to bring about a true infectious diarrhea in an indirect way. The distinctions between the three groups are, in the main, however, fairly clear cut.

It is of great practical importance to bear in mind these dis-

tinctions, as the feeding for the different sorts of diarrhea may be entirely different; what is proper for an infectious case might be fatal in a fermentative one. I cannot emphasize too strongly that not all infantile diarrheas are the same, and that they should not all be treated in the same routine manner. The first essential is a correct diagnosis, and in order to arrive at this the etiology of the three groupings must be thoroughly understood.

MECHANICAL DIARRHEA

This type of diarrhea is fairly common, and is more likely to be seen in children above the age of one year than in those younger. It is caused by mechanical irritation of the delicate intestinal mucosa from such things as grape skins, cucumbers, and raw fruit. It is a common practice among many ignorant people to feed all sorts of indigestible foods, particularly raw fruit, to small children from one to five years of age long before they are ready for it. Some children seem to be able to stand this, but the majority cannot, and no raw fruits should be fed to any child under five years old. In many cases the mechanical irritation of the intestine paves the way for organisms to attack it in the irritated places, so that often a mechanical diarrhea may change to one of the true infectious type. A typical case of mechanical diarrhea would run about as follows: A child of two is given a peach to eat, skin and all. The peach may be ripe or it may not be. Soon after the child is taken severely sick, with vomiting and diarrhea. The stools are usually five or six in the twenty-four hours, and are likely to contain undigested peach pulp and skin. The vomiting may be so severe as to be uncontrollable, and it is in this type of diarrhea that gastric disturbance is most common. In some cases there may be a tremendous amount of toxemia, and not infrequently these children die, partly from acidosis caused by the severe vomiting and partly probably from the absorption into the circulation through the injured intestinal wall of toxic material or possibly bacteria from the intestine. Every practitioner of experience has seen cases such as this. Last summer I saw a boy of six at

the Children's Hospital who died in forty-eight hours from eating a raw cucumber. In ordinary cases the child will be well in two or three days, and the diagnosis and treatment offer no difficulty save in those cases which develop infectious diarrhea.

The treatment consists simply in purging the child with castor oil or calomel, putting him to bed, giving him barley-water or some other gruel for twelve hours, with plenty of water, and then starting him on a bland, non-irritating diet of cereal and boiled skimmed milk. This is the simplest and least important of the infantile diarrheas.

FERMENTATIVE DIARRHEA

This is a more complicated and important condition, and is the most common diarrhea of babies. It is most likely to occur in children under one year, but may be seen at any age. It is brought about by abnormal decomposition of food in the intestine, caused either by the bacteria which are already there or by bacteria introduced from without. The products of fermentation irritate the intestinal mucosa and cause a diarrhea, but the mucous membrane is not attacked by bacteria. The abnormal decomposition is usually that of sugar, and may be caused in several ways. In order for sugar fermentation to occur two conditions must exist: unabsorbed sugar in the intestine and bacteria in the same portion of the intestine to attack it. Under normal conditions the small intestine is relatively sterile, the large intestine is swarming with bacteria. Therefore, any conditions that allow a considerable amount of undigested sugar to proceed lower than is normal in the digestive tract, or which will allow bacteria to flourish in the small intestine, where there is always unabsorbed sugar, will bring about sugar fermentation. Let us consider some of these conditions.

Overfeeding with Sugar.—If too high a percentage of sugar, or if too much food, thus giving a large amount of sugar, is fed to a baby, all of the sugar cannot be absorbed. What is not absorbed passes into the lower part of the intestine and the ever-ready bacteria there attack it and ferment it.

"Parenteral" Infections.—It is well known by every practitioner that babies suffering from such affections as rhinitis, bronchitis, or otitis media are likely to have loose, greenish stools. The probable reason for this is that in these conditions the digestive juices are reduced in amount, so that sugar is not digested so well as normally and thus is fermented; or that under the general debilitating influence of any extra intestinal disease the intestinal mucous membrane loses some of its antibacterial power and thus allows bacteria to flourish higher in the intestine than they would normally.

Overheating of the body is an important cause of sugar fermentation. This is well known clinically and has also been proved by animal experimentation. The practice of dressing babies too warm in hot weather is undoubtedly the cause of a good many cases of sugar diarrhea. The explanation of this is probably very similar to that for "parenteral" diarrhea. Owing to the debilitating heat, the digestive juices are lessened in amount, and the efficiency of the mucous membrane is impaired in such a way that undigested sugar is permitted to pass down where bacteria can get at it, or the bacteria are allowed to come up and flourish where the sugar is.

Nervous Exhaustion and Excitement.—These may bring about sugar fermentation, probably in a way similar to that in which it is brought about in the last two conditions I have discussed. However, it is not a particularly frequent or important cause of sugar fermentation.

Constitutional Weakness.—There are certain babies who, on account of constitutional weakness, never seem to be able to take much sugar, or, indeed, much food of any sort without diarrhea. It is probable that their digestive juices are inefficient, and that there is always a great deal more bacterial growth in the small intestine than there should be.

Infected Milk.—The types of sugar fermentation enumerated above are all brought about by the normal intestinal bacteria's taking advantage of the abnormal conditions of the host. The next and by far the most important type of sugar fermentation

is caused by abnormal bacteria introduced from without in bad milk. Bad milk is probably the most potent source of sugar fermentation, and gives rise to the most severe cases of diarrhea. There is probably no specific organism that accomplishes this, although investigators have tried at various times to look on the condition as a specific infection. A great many different sorts of bacteria, when introduced into the small intestine, may bring it about, and probably two of the most common offenders are the Bacillus aërogenes capsulatus (gas bacillus) and the colon bacillus.

The foregoing will serve to show the main causes of sugar fermentation; let us now see what chemical processes are involved. When sugar is fermented by bacteria, acids are formed. These may be divided into two groups: the volatile acids, such as formic, acetic, and butyric, and the non-volatile acids, such as lactic and succinic. The volatile acids particularly are formed in large amounts, and are the ones which do the most harm. The non-volatile acids are relatively harmless. It is surprising to see how much free acetic acid may be recovered from the stools of some babies with sugar fermentation, and when one takes into account its extremely irritating nature it is easy to see how much damage may be done. The volatile acids cause harm (1) by increasing peristalsis and causing a diarrhea by irritating the intestinal mucosa; (2) by injuring the mucosa in such a way that its antibacterial function is impaired, or to such an extent as to allow toxic material from the intestine to pass through into the general circulation, a thing which would never happen normally; (3) by drawing on the alkali reserve of the body in an attempt to neutralize the excessive acidity, thus probably helping to cause an acidosis; and (4) by upsetting the normal chemical processes of digestion, most of which cannot go on satisfactorily in an excessively acid intestine.

Degrees of Sugar Fermentation.—Sugar fermentation may occur in three degrees of severity, which vary a good deal in their chemical conditions and clinical appearance:

1. The condition may be of a very mild type, in which a

normal baby has two or three very acid stools a day of a consistency rather looser than normal. These stools may be of the normal color, or slightly greenish, with usually only a little mucus. The baby is not sick, the condition is a very mild one, and almost always clears up readily with proper treatment. Its importance lies in the fact that untreated, the condition may become severe, and may ultimately lead to most serious results. This may be seen at any time of year and probably has nothing to do with bad milk (cf. Sugar Indigestion).

2. It may be a more severe condition, usually seen in the summer during a "muggy spell," but may occur at any time. The baby will have from five to ten very loose, green, acid stools a day, containing a good deal of mucus, and many small soft curds of undigested milk. The stools may contain a few flecks of bright blood, but this is not usually large in amount, and does not persist for more than a few days at the most. He is fussy and irritable, but is not very sick in most cases. His buttocks are likely to be red and excoriated from the excess of acid in his stools. The temperature is usually from 99.5° to 101° F. In this section of the country, at any rate, this type of diarrhea is caused more often by bad milk than in any other way. In other sections where all milk fed to babies is boiled as a routine, it may be more often caused by some of the other agencies already enumerated. The condition is a local intestinal one; the intestine has been irritated, the processes of digestion have been disturbed, but the baby's body chemistry as a whole has not been upset. The process has as yet caused no trouble further than in its original locus, the intestine. If the patient is properly treated, the disease should be arrested without difficulty; improperly treated or neglected, the baby may pass over into the state which I shall call Stage 3, a much more serious condition ("alimentary intoxication").

3. In this case the baby is very sick. He usually has a high temperature, but in certain cases he may be so prostrated that the temperature is subnormal. The fontanel, abdomen, and eyes are sunken, the skin hangs loosely on the flesh, and has

lost its elasticity—all from a loss of water. There is a profuse watery diarrhea, ten to twenty stools in the twenty-four hours. The baby takes no interest in his surroundings, his mentality is very dull, and he may be roused with difficulty. The breathing is deep and sighing (hyperpnea) and the urine may show sugar and casts. This is the picture of "alimentary intoxication," and a most precarious and serious condition it is. Here the process originally starting as a local intestinal condition has progressed so that it has changed the general metabolism, and has perverted the chemistry of the entire body. There is a negative nitrogen and salt balance, there is loss of a large amount of fluid, very often severe acidosis, and last, but not least, it is probable that many injurious substances from the intestine are absorbed into the general circulation through the injured intestinal mucosa, thus adding to the severity of the condition.

Treatment in Very Mild Cases.—Many normal babies are likely to have periods of mild sugar fermentation occasionally. In nearly all the following simple treatment will clear the condition up, often in twenty-four hours, and will prevent the development of a severe sugar fermentation. A purge is not necessary unless the baby has fever, and this is uncommon. All sugar should be omitted from the milk modification, and the solution boiled for three minutes; $\frac{1}{4}$ teaspoonful of precipitated chalk should be added to each bottle.

Usually after twelve or twenty-four hours of this feeding the stools will return to normal, when sugar can be added gradually, and in two or three days the baby will be back on his regular modification.

Treatment in the More Severe Cases.—Groups 2 and 3 may be considered together in the discussion of treatment.

Purgation.—It is a mistake to give a purge as a routine in every diarrheal disease. If there is any harmful material in the intestine which is not coming out as fast as it should, a purge ought to be given—otherwise not. It is not rational to purge a baby who is already having a great many loose stools a day

and whose intestine is emptying itself of toxic material as fast as it possibly can. In such cases castor oil or calomel adds insult to injury. On the other hand, a baby who is seen at the onset, who has fever, and who has not as yet been emptied by diarrhea, ought to be purged at once, and it is often striking to see how the temperature will drop and how much more comfortable the baby will be after a good cleaning out.

Feeding.—This is the most important part of the treatment, and it is in this that mistakes are most frequently made. After the initial purge the baby should be deprived of food for about twelve hours, being offered nothing but weak barley-water. Many babies will take this readily when they will not take plain water. The object of the starvation is to empty the intestine as completely as possible and to discourage the further increase of bacteria by offering them no food on which to grow. Starvation must not be used, however, in very weak or toxic cases. The principles of feeding are the same in every case of sugar fermentation; the details may have to be modified according to circumstances.

The condition we are dealing with is caused by an excess of acid in the intestine from the fermentation of sugar by some organism or group of organisms which thrive on sugar. Such organisms are likely to be greatly diminished or to die out if their principal food supply is withdrawn. Therefore, the great principle in treatment is to offer a food which contains very little sugar, and a considerable amount of protein, for, as a rule, the organisms that thrive on sugar do not thrive on protein. Such a food can be prepared in a number of ways, depending largely on the resources of the people one is dealing with.

PROTEIN MILK.—This, or a modification of it, is the ideal food, and babies with sugar fermentation do better on it than on any other. It is too difficult of preparation to be used among the ignorant, but an intelligent mother can make it satisfactorily. There have been numerous modifications of protein milk, but the original preparation is probably as satisfactory as any. It is made by rubbing the curds from a quart of milk (prepared

with essence of pepsin) through a fine sieve several times until they are in a finely divided condition (see Chapter IX). These curds are then mixed with a pint of buttermilk diluted with a pint of water. The resulting mixture contains fat 2.5 per cent., sugar 1.5 per cent., protein 3.5 per cent. In using all the high protein, low sugar milks, dextrimaltose should be added up to 3 per cent., as if no sugar at all is taken, acidosis may result. Such a mixture as this offers but little sugar for the sugar-splitting bacteria to grow on, and on account of its high protein content it tends to make an alkaline intestine; in an alkaline intestine calcium soaps tend to be formed, which favor the formation of pasty, semisolid stools. The protein milk should be fed in very small doses at first—perhaps one-fourth as much protein milk as the usual amount of milk the baby would take, with the balance made up of water. If it is borne well, the amount may be rapidly increased. As the baby improves and as the bowel discharges become less frequent, small amounts of sugar may be gradually added. The best sugar to use is some maltose-dextrin preparation, as it ferments less readily than lactose does. Protein milk is only a temporary food and should not be continued longer than a few weeks.

In a large city where there is a milk laboratory it is usually simpler to have the milk prepared at the laboratory from cream, water, and precipitated casein, as any amount of casein or of fat desired can be obtained in this way, thus better suiting the preparation to the digestion of the individual baby than when a stock formula is used. Such a formula prepared at a milk laboratory would be as follows: Fat 2, sugar 0,[1] precipitated casein 2.50, lactic acid 0.75. In all cases it is well to use about 3 per cent. of dextrimaltose, as the entire or almost entire withdrawal of sugar may be dangerous on account of the possible aggravation of an already existing acidosis. Nor is it well to use a very low sugar in any case for more than a day or two.

Skimmed Milk with Powdered Casein.—Another satis-

[1] In reality, there is a small amount of sugar present, furnished by the cream used in preparing the formula.

factory and eminently practical and simple way of feeding is with simple dilutions of skimmed or whole milk to which powdered casein has been added. In the summer of 1915 I fed a good many out-patients by this method, and got very good results, fully as good, I believe, as could have been obtained with the more complicated "protein" milk. The chief advantage of the powdered casein method is its extreme simplicity, and it is probably the best method for general use of obtaining a low sugar and a high protein formula. The powdered casein mixes very readily with milk and water to form a gruel, and in this way it is possible to secure any percentage of casein desired in combination with a sufficiently low sugar. The usual dilution employed would be:

Skimmed milk, one-half.
Water, one-half.
Powdered casein, up to 2 or 3 per cent.

This method of feeding is of real importance, and should be familiar to every practitioner. There are at present at least three powdered casein preparations on the market (see Chapter IX).

Lactic Acid Milk.—In some cases lactic acid milk or buttermilk feeding may be of value, the idea being that the lactic acid organisms of the buttermilk flourish in the intestine and supplant the organisms that are doing the damage. Buttermilk, also, is not very rich in sugar, and contains a good deal of protein in an easily assimilable form. It is not possible, however, to secure with buttermilk dilutions the high protein percentage that can be obtained with the methods already referred to. Unless fresh buttermilk can be obtained it is best prepared at home from skimmed milk and cultures or tablets containing the lactic acid or Bulgarian bacillus. If it is desired to use the lactic acid principle, that is, flooding the intestine with lactic acid bacilli, it is a great deal better to give the bacilli in the form of lactic acid milk than to use simply tablets or vials of the culture, as infinitely more bacteria can be given in the first way than

the second. It is worth while, however, if after persistent trial, the baby refuses the sour milk,[1] to try the liquid cultures, one-half a tube three or four times a day. The tablets I have no faith in.

The lactic acid milk plan of feeding is used a good deal, and in some cases is very efficient, particularly if the intestinal contents are infected with the gas bacillus.

Simple skimmed milk dilutions (boiled) are the best thing to use if a high protein milk or lactic acid milk cannot be obtained. One would begin with one-third or one-half skimmed milk, the rest being barley-water or water, and would increase the concentration of milk gradually as the stools became better. By this method improvement is not so rapid as it is with a high protein milk or with lactic acid milk, but where no facilities for anything better are at hand or in dealing with very ignorant patients, it works fairly well.

Medicinal and Other Treatment

Colonic Irrigations.—If seen at the onset, a high colonic irrigation with physiologic sodium chlorid solution may do a great deal of good by helping to empty the intestine. Later in the course of the disease it does less good, and, indeed, is likely to do more harm than good by irritating and disturbing the child.

Water.—Next to the feeding, the free administration of fluid is of the utmost importance. The baby is losing a large amount of fluid from the body in the water discharges, and it is vital to the chemistry of the body, for many reasons, that the blood and tissues should not be dehydrated. Howland and Marriott believe that a large amount of the acidosis that is seen in these cases is caused by retention, owing to anuria, of acid sodium phosphate. Marriott has also shown that the blood is very much dehydrated in all cases with evidences of intoxica-

[1] Almost all small babies take lactic acid milk readily. Many babies over a year old refuse it at first, but if no other food is given, usually will take it when they get hungry.

tion, and he believes that most of the toxic symptoms are caused by dehydration. He has even substituted the term "anhydremia" for "alimentary intoxication." It may be seen, therefore, that at all costs the tissues must be prevented from becoming dehydrated. There are four ways of giving fluid to babies with diarrhea:

By Mouth.—This is, of course, the simplest way, and directions should always be left with the mother or the nurse to get in all the water possible between feedings, in frequent teaspoonful doses, and to keep an exact chart of the amount that

Fig. 5.—Sodium bicarbonate. Subcutaneous slough. (Courtesy of Dr. Hyman Green.)

has been taken. If the baby will take fluid well in this way, and is not already "dried out," it will not be necessary to resort to the other methods of giving it.

Subcutaneous Saline.—The subcutaneous injection of normal saline was formerly the method of choice, but has now been largely replaced by the intraperitoneal method. In giving saline subcutaneously it is best given in the loose tissues of the abdominal wall, and not subpectorally, as the weight of the fluid on the chest may use up some of the infant's scanty store of strength. It is given with an ordinary large glass syringe,

about an 18 gage needle, and a three-way stop-cock, or may be allowed to run in by gravity. From 60 to 120 c.c. can be given on each side of the abdominal wall, depending upon the size of the child. It is readily absorbed, unless the child is in an extremely weakened condition, and in a very short time after injection no traces of the fluid are to be seen in the tissue. *Sodium bicarbonate should never be given subcutaneously, as it is very irritating, and will almost certainly cause a severe slough* (Fig. 5).

Intraperitoneal Saline.—In the last three years the intraperitoneal administration of fluid[1] has come into vogue. It apparently is without danger if properly performed, and has several advantages over the subcutaneous method. In the first place, it is not nearly so painful, and does not upset or irritate the child so much. This is a considerable advantage, as it may be repeated every twelve to twenty-four hours, if necessary, without undue discomfort. In the second place, more fluid can be given in this way than by the subcutaneous route. and, according to the size of the baby, 200 to 400 c.c. may be injected. Lastly, it is probably absorbed more quickly, especially in very weak, moribund babies, who may have little power of subcutaneous absorption. The same apparatus is used as for the subcutaneous injection except that the point of the needle should be rather blunt. It is inserted in the midline somewhat below the umbilicus, care being taken to see that the bladder is empty, and that the abdomen is not distended. The fluid is injected slowly, or allowed to run in slowly if given by the gravity method, which is perhaps the best for this procedure, as if it is put in too quickly there may be some danger of collapse. Fluid is given until the abdomen is slightly distended. There is apparently no danger of puncturing the intestine.

[1] Physiologic saline solution is used at a temperature of about 100° F. A teaspoonful of salt to a pint of water makes approximately a normal solution, of about 0.80 per cent. strength. It should, of course, be sterilized by boiling before administration, and every aseptic precaution strictly observed as regards the apparatus, skin of the patient, and hands of the operator.

Intravenous injections are especially useful when it is desired to give glucose or soda bicarbonate for acidosis, or when immediate availability of the fluid is essential. A 3 per cent. solution of sodium bicarbonate or a 5 per cent. solution of glucose is used, and an amount injected equal to about one-sixtieth of the body weight (Dunn). It is best given into the veins of the scalp, or the jugular, if these are available. If not, it may be given into the superior longitudinal sinus, a procedure which is comparatively safe, and very easy to carry out, but which, in my opinion, should not be used if the other veins are available. A short, blunt needle, attached to a large syringe, is inserted at an angle of about 45 degrees in the midline, at the posterior angle of the fontanel. The piston of the syringe is slowly withdrawn a little, and if the needle has entered the sinus, blood will appear on the syringe. The injection should be made very slowly, and if the pulse or respiration become poor, or if distention of the veins of the scalp appear, should be stopped.

Drugs.—*Precipitated Chalk.*—This is, I believe, of considerable value, as it helps in neutralizing the irritating acids that have been formed in the intestine; $\frac{1}{4}$ teaspoonful can be given mixed with each feeding. The soluble alkalies are useless to give for this purpose, as they are largely absorbed in the stomach and never reach the intestine.

Opium.—It is often difficult to know whether or not to give opium. It is contraindicated if the bowel movements are few in number, if there is a high fever, or if there is much evidence of toxemia. It is always contraindicated at the onset of an attack, as it is essential to empty the intestine and not to tie it up. In other cases it is distinctly indicated, and it is not good therapeutics to slavishly follow a set rule and to refuse to give opium in any case of diarrhea, as an experienced practitioner did with whom I once saw a case in consultation. The child had been sick over a week, and was having from twenty to twenty-five movements a day, with a great deal of tenesmus and discomfort. She was much exhausted from all this, and

still the doctor refused to give the small doses of paregoric which I suggested because he "knew it was always wrong to give opium in any diarrhea." In such a case as this opium in some form, preferably paregoric, is distinctly indicated, for although diarrhea is undoubtedly a conservative process, it may exhaust the child so much that it does him more harm than good.

Bismuth.—This drug is sometimes highly recommended, and, again, many authors say it is useless. It probably does more good in the true infectious type of diarrhea, where there is actual ulceration of the intestine, than in the fermentative type which we are discussing; in those diarrheas due to sugar fermentation I should much prefer precipitated chalk.

Stimulants are often needed, and there is probably none better than brandy or caffein. Epinephrin has been highly recommended by some, but its action is so transitory that its value seems somewhat doubtful, except to tide over a sudden collapse.

The **electric fan** is better than most drugs in the treatment of any severe diarrheal disease in a baby in very hot weather. The baby should be, of course, dressed very lightly in a band, diapers, and cotton night dress. The fan should not blow directly on the baby, but should be put on a chair or table, and directed so that the air from it will blow about 2 feet over him. There is no danger of "catching cold" if this rule is observed, and a fan is a great comfort to any baby, especially at night, in very hot weather, whether he is sick or well.

Excoriated Buttocks.—If the buttocks are badly excoriated it is best not to use a diaper, but merely to put a pad of absorbent cotton under the baby, and change it after each defecation. Each time the pad is changed the buttocks should be gently washed with water and dried. In my experience the two best applications have been the following:

1. Two ounces of lime-water and 2 of olive oil are put into a bottle, are shaken vigorously immediately before each application, and the resulting emulsion smeared frequently over the buttocks.

2. ℞. Bismuth subcarbonate ...... ʒij;
Lime-water .... q. s.
Anhydrous lanolin ....ad. ℥ij.—M.
S.—Apply locally.

This makes a very thick, sticky paste, and acts as a very efficient protection to the excoriated skin.

Protein Form of Fermentative Diarrhea

The protein form of fermentative diarrhea is not nearly so common as the carbohydrate form. In this condition the intestinal contents have been infected with bacteria which feed mostly upon protein, and the resulting stools are brown, foul, and alkaline instead of being green, sour smelling, and acid. The general symptoms are similar to those of the carbohydrate form, but the differentiation of the two should offer little difficulty owing to the difference in the stools. The treatment is the same with the exception of the feeding. Here a low protein and a fairly high carbohydrate diet is needed. Ordinary milk modifications with low protein and high carbohydrate added in the form of lactose and starch sometimes work very well. Lactic acid milk dilutions with the addition of lactose and starch are also valuable. This diarrhea is more likely to be caused by organisms introduced from without in bad milk than to any faulty digestion on the part of the baby.

INFECTIOUS DIARRHEA

In this disease we are dealing with a true infection of the intestinal mucosa due to some specific organism, usually the dysentery bacillus, but occasionally the gas bacillus or streptococcus. Combined with infection of the mucosa there may be also a certain amount of decomposition of the intestinal contents. The condition has been called by many names, but the term "infectious diarrhea" is the best one, as it serves to differentiate it from the fermentative group of diarrheas. Infectious diarrhea may arise in a number of ways, the most common one probably being direct infection of the mucosa by dysentery bacilli taken in per os. Or the process may in many cases start as a fer-

mentative diarrhea, and for the first few days there may be no invasion of the mucosa. Then, if the organisms gain ascendance and are of the right variety, the already irritated mucosa is attacked, turning the fermentative diarrhea into one of the true infectious type. Occasionally a mechanical diarrhea may change into an infectious, owing to the fact that the mechanical irritation of the intestine prepares the way and allows bacteria to invade the injured mucous membrane. There has been much discussion as to the organisms that cause infectious diarrhea, but the consensus of opinion is that most cases are due to the dysentery bacillus. The streptococcus and the Bacillus aërogenes capsulatus are also probably etiologic agents in some cases. Infectious diarrhea is often a true epidemic disease, and is spread for the most part in the same way that typhoid fever is spread—by "fingers, food, and flies."

In Boston the epidemic usually starts the middle part of July, continues through August, and in especially hot summers into the first part of September. In the South it starts earlier, the last part of May and the month of June usually being the worst months. Isolated cases may, however, be seen at any time. Young babies are by no means immune, but more cases of infectious diarrhea are seen in babies over nine months old than in those under. The reverse is true for fermentative diarrhea. Older children are likewise not infrequently attacked. In fermentative diarrhea there is usually no demonstrable pathologic lesion of the intestine, save perhaps a certain amount of reddening of the mucosa; in infections diarrhea there may be a severe catarrhal or membranous inflammation of the mucosa of the lower part of the ileum and of the colon, or innumerable small punched-out ulcers may be seen. The mesenteric lymph-nodes are usually enlarged and injected, and dysentery bacilli have in some cases been recovered from the blood. Secondary streptococcic infection is not uncommon, which may cause septicemia, bronchopneumonia, or otitis media.

Symptoms.—The onset of infectious diarrhea is varied. It may be very sudden in true dysentery infections where the

offending organism is of a virulent strain, and I have seen a case start with a temperature of 105° F., with no diarrheal symptoms until the next day. In most cases the onset is more gradual, however, and is first made known by diarrhea and moderate fever. There will usually be about eight or ten stools a day, but in some cases there may be as many as twenty. The stools at first are large, and may contain no blood, resembling those of fermentative or mechanical diarrhea. In the course of a day or two blood begins to appear, and is practically always present during the course of the disease, mixed intimately in bright red streaks with the mucus and pus. The stools may be very small and often contain no fecal material, but consist merely of mucus, pus, and blood. They are not usually offensive in character, and are more likely to be alkaline than acid in reaction owing to the large amount of mucin they contain, which is a protein and decomposes rapidly. There is always a certain amount of putrefaction of mucus, pus, blood, and other intestinal secretions going on, and there may be added to this in certain cases a considerable fermentation of carbohydrate food within the bowel, in which case the stools will be strongly acid in reaction and will smell sour.

The condition varies a great deal in its severity, according to the virulence of the offending organism. Many patients do not have a temperature above 101° F., only slight evidences of toxemia, and do not seem very sick, but still have many typical stools every day. Others will show extreme toxemia, with high temperature from the start, and may die in a few days despite all efforts at treatment. *Toxemia and not the number or character of the stools is the criterion of the severity of the case.*

There are likely to be colicky abdominal pains, and a good deal of very uncomfortable rectal tenesmus with each movement of the bowels, accompanied in not a few cases by prolapse of the rectum. Nervous symptoms, such as twitching, convulsions, delirium, and retraction of the neck, are not uncommon in severe cases, and are of bad prognostic significance. The body rapidly becomes drained of fluid on account of the diarrhea,

and acidosis may develop, as shown by hyperpnea, in much the same way that it does in diarrhea of the fermentative type. Gastric disturbance at the onset is common; during the course of the disease it is the exception rather than the rule, but when present may be rather hard to control. The most common complications are bronchopneumonia, pyelitis, and otitis media.

Diagnosis.—It is rare to see a case of infectious diarrhea without blood and pus in the stools, and for practical purposes this is the best way of distinguishing it from fermentative diarrhea. In the latter condition blood in the stools may be seen, but there is never very much of it, and it never lasts long. Large amounts of macroscopic pus are usually seen in infectious diarrhea, while in fermentative diarrhea such an occurrence is not so common. The temperature curve is also of considerable assistance in diagnosis. It may be high or low in either condition, but in fermentative diarrhea it rapidly drops as soon as the intestine is emptied and proper feeding instituted. In infectious diarrhea, on the other hand, the temperature is likely to continue for a week or more, in spite of purgation and proper feeding.

On account of the bloody stools in both conditions intussusception is not infrequently confused with infectious diarrhea, the usual mistake being to overlook the intussusception and to call it infectious diarrhea.

The following table shows some of the main differences between the two conditions:

	Infectious Diarrhea.	*Intussusception.*
Onset:	Usually with a fermentative diarrhea, or if sudden, with a good deal of fever.	Sudden, without fever or diarrhea at first. Blood appears soon in the stools. Abdominal pain marked.
Temperature:	Usually elevated.	May be normal.
Vomiting:	Usually not marked.	Marked—may be fecal.
Distention:	Not distended, more likely a sunken abdomen.	Markedly distended in most cases.
Abdominal tumor:	None.	Sausage-shaped tumor felt in four-fifths of cases.

Treatment.—The general treatment is much the same as that for fermentative diarrhea, which has already been outlined. The principles of feeding, however, are quite different. As regards diet, cases of infectious diarrhea must be divided into two groups, for the feeding in the two groups is radically different. The first group includes cases caused by the dysentery bacillus, or more rarely by the streptococcus or possibly the colon bacillus. The second group is caused by the gas bacillus (Bacillus aërogenes capsulatus).

As far as the symptoms and gross characteristics of the stools are concerned, it is impossible to tell into which group a given case falls. However, there is a simple stool test (see below) which serves to differentiate these groups. While the stool test is being made, or if for any reason it is not made, the case should be treated as a dysentery case, for this is by far the most common type. The therapeutic test is of some value, although rather haphazard, and if the child does not do well on the dysentery treatment, it should be changed to that for the gas bacillus. It is always best at the onset, however, to test the stools for the gas bacillus, as the test is simple, and it gives much valuable information as to the proper feeding.

Technic of Gas Bacillus Test.—A U-shaped fermentation tube and a test-tube are filled with concentrated nitric acid, and permitted to stand three minutes, when the nitric acid is poured out. Both tubes are rinsed thoroughly with tap-water.

A small bit of stool, about $\frac{1}{2}$ teaspoonful of dextrimaltose, and about 15 c.c. of hot tap-water are placed in the test-tube, and the mixture is boiled vigorously for half a minute. The contents of the test-tube are now poured into the fermentation tube, care being taken that it is filled up to the top, and that no air-bubbles remain in it. The tube is plugged with flamed cotton and kept in a warm place for twenty-four hours.

Gas in the top of the tube indicates that the gas bacillus is present in greater or lesser numbers, depending on the amount of gas formed. If the gas bacillus is present in sufficient num-

bers to be the etiologic agent of the diarrhea, the tube will probably be "blown out," that is, entirely filled with gas.

Another simple way of testing for the gas bacillus is to plant a portion of stool in half a test-tube of boiled milk and incubate twenty-four hours. If the gas bacillus is present the milk will be coagulated, will smell like rancid butter, and will be shot full of holes like Swiss cheese.

If the "gas test" is negative, assume that the case is one of dysentery infection, and treat it as such.

Feeding in Dysentery Cases.—The feeding in these cases is based on the fact that when offered protein food the dysentery bacillus grows very readily and produces large amounts of toxin. On carbohydrate food it does not produce so much or such deadly toxin. This applies likewise to the streptococci and pathogenic colon bacilli which are commonly associated with dysentery infections. Therefore a baby with dysentery should be fed on a low protein and a high carbohydrate food. This is theoretically sound, works well in practice, and is probably the most successful feeding known for dysentery patients. A few years ago it was the custom to starve patients with infectious diarrhea, and we used to feed many on weak barley-water or lactose-water exclusively for a week or ten days. Many of these patients died, probably as much from starvation as from the disease. During starvation the bacteria causing the disease live upon the intestinal secretions, which are protein in character, and from which they can readily produce toxin. The old treatment with albumen-water and meat broths is distinctly contraindicated.

According to our present ideas a year old baby with dysentery would be treated about as follows:

Purgation.—A brisk purge at the onset is distinctly indicated in order to empty the bowel of as much toxic material as possible. Castor oil is the best purge if it can be kept down, and a tablespoon would be given to a year old baby. If the stomach is irritable, calomel is used, in ten divided doses of $\frac{1}{10}$ grain each, and followed in about two hours with two teaspoonfuls of milk of magnesia. During the course of the disease routine purga-

tion should not be used, but should be employed only if the number of stools have lessened and the toxemia has increased.

Starvation.—For twelve hours all food except water is withheld. This is in order to thoroughly empty the digestive tract, and during this stage the water should be forced, in small frequent doses.

Feeding.—After the initial starvation period a 7 or 8 per cent. lactose solution in barley-water is given, 6 to 8 ounces every $2\frac{1}{2}$ or three hours. This would ordinarily be kept up twenty-four to forty-eight hours. Then the regular feeding is begun, the principle being to add small amounts of protein in the form of boiled skimmed milk or fat-free lactic acid milk, to the lactose and barley-water solution, and to gradually increase it during the course of the disease, as the stools become better. Lactic acid milk is, I think, usually a good deal more efficient than ordinary skimmed milk. One would begin with a formula of about the following strength:

Fat-free lactic acid milk,	2 ounces.
Barley-water,	6 ounces.
Lactose,	up to 7 or 8 per cent.

If lactic acid milk is not available, dried milk or boiled skimmed milk would be used. Condensed milk would also be suitable. As the baby begins to improve, and as the stools become less frequent and more normal in character, the strength of the formula is increased, until it would consist of undiluted or only slightly diluted fat-free lactic acid milk, with lactose added up to 7 or 8 per cent. At this stage a few tablespoonfuls of barley or rice jelly a day is added, or zwieback soaked in fat-free milk. The last thing to do is to increase the fat in the mixture, as these babies bear fat very poorly, and many cases of chronic indigestion have been caused by adding fat too soon and in too large amounts. The loss of weight is, of course, considerable, and the natural tendency is to push food, but it is far better to go slowly and cautiously, and to avoid the danger of a relapse. Not a few cases of severe marasmus follow over-

feeding during the convalescent period of infectious diarrhea. After the stools become normal it is best, if the baby is doing well on the lactic acid milk and lactose mixture, to continue it for some weeks, with the addition of 1 or 2 per cent. of fat, rather than to try to get him back rapidly to ordinary whole milk. If during the course of treatment the stools should become more frequent, acid, and sour smelling, this is an indication that too much sugar is being given, and that it is being fermented. Under these conditions a reduction or entire omission of the lactose for two or three days is indicated. It is quite likely that the baby will not digest all the food that is given him under this regimen, but he will come through the disease in much better condition than if he is starved, as under the older method of treatment. The feeding in the "gas bacillus" type of case is different, and patients with this form of infectious diarrhea always do better on lactic acid milk with a *low sugar* content than with any other form of feeding. The lactic acid bacillus seems to be directly antagonistic to the gas bacillus, and drives it out of the intestine very quickly. Furthermore, the relatively low carbohydrate and high protein content of lactic acid milk is indicated, as the gas bacillus is an organism which thrives on carbohydrate food, but does poorly on protein. Protein milk, which has already been discussed in the section on Fermentative Diarrhea, likewise fulfils the indications for feeding in this group of cases.

The exact relationship of the gas bacillus to infectious diarrhea is under some dispute, and some observers believe that it is not at all the etiologic agent of the disease, but merely present as a relatively inoffensive saprophyte. We know, at any rate, that it is not infrequently present in large numbers, and that when we get rid of it by lactic acid milk and low sugar feeding, the patient is better. These facts are enough upon which to base an intelligent therapeusis, no matter what its exact relationship to the disease may be.

Other Methods of Treatment.—*Colonic Irrigations.*—A colonic irrigation at the onset probably does considerable good.

During the course of the disease I am very doubtful about its value, and it may do more harm than good by irritating and disturbing the child. Rest and quiet are two of the most important principles in the treatment of any disease. If the child, however (especially an older child), is restless and disturbed at night on account of tenesmus and frequent bowel movements, a colonic irrigation with warm normal saline at about 7 or 8 P. M. may get rid of enough mucus and may be soothing enough to the lower part of the bowel to prevent such frequent movements, and to give him some sleep for the first half of the night at any rate. Also, in subacute cases, where pus, mucus, and a little blood continue in the stools longer than they should, irrigations once a day with a pint of 2 per cent. silver nitrate solution may be of considerable value.

Drugs.—*Bismuth* seems to do good in some cases, probably by coating over the little ulcers in the intestine. The subcarbonate is the best form to use, and should be given in relatively large doses (grs. xx or xxx every three hours) with the feeding.

Tannalbin is an organic preparation of tannic acid, and is astringent in its action. It is brown in color, inoffensive in taste, and may be given either in the form of pills or of powders. The dose is about 10 grains every three hours or 15 grains for older children. In a few cases I have seen it apparently help a good deal by lessening the amount of blood in the stools. It is worth a trial.

Opium.—The same holds true of opium for infectious diarrhea as for fermentative. It is often recommended to give opium enemas or suppositories. What the rationale of this is I am sure I do not know, as opium is not a local anesthetic, and it works no better on the rectum or intestine when given in this way than when given by mouth. Furthermore, it will probably not be retained. It is always best given by mouth in the form of paregoric, or subcutaneously in the form of morphin, if the stomach is irritable.

Fluid.—The same as for fermentative diarrhea.

Treatment of Special Symptoms.—*Vomiting* may be in a few cases a very troublesome symptom. It is best treated by temporary withdrawal of food, beginning again with very small, frequent doses. An old country doctor in the South told me once that small doses of calomel were effective, which from later experience I have found to be true in some cases. If these two measures are unavailing, stomach washing with a 1 per cent. soda bicarbonate solution (about 1 rounded teaspoonful to the pint) should be tried.

Hyperpyrexia.—If the temperature is continuously high (105° F.) measures should be taken to reduce it. The best method is the cool pack. The baby is wrapped in a large bath towel or old blanket wrung out in water at about 80° F. Water of this temperature or a little lower is sprinkled over the wrapped-up baby, and evaporation caused by fanning with a hand fan or still better by an electric fan. This is often very efficient both in controlling hyperpyrexia and nervous symptoms. Ice-bags to the head are not usually very practical for small babies.

Nervous Symptoms.—Cases with high fever and marked toxemia often show severe nervous symptoms. Sodium bromid by mouth or cool packs are the best measures of treatment. If these do not work, codein may be given subcutaneously. This is much to be preferred to morphin in any form, as it does not tie up the intestine nearly so much as does the latter drug. Chloral is usually not practical, as its taste is very disagreeable when given by mouth, and it may upset the stomach. Rectal administration is, of course, not suitable in the presence of a diarrhea.

Collapse.—For sudden collapse subcutaneous injections of adrenalin are as good as anything for quick action, but the effect is transitory. Brandy, whisky, caffein, camphor, and strychnin are also all commonly used. Small doses of brandy or whisky are as good as anything.

Prognosis.—Infectious diarrhea should always be considered a serious disease, although it does seem, in this locality,

at any rate, that it has been milder in the last few years than formerly. The prognosis depends mostly on the age and general condition of the child and on the virulence of the infection. Babies who have previously suffered from chronic digestive disturbances are always poor risks, and if they do not die from the acute attack, they are not unlikely to develop marasmus and die later. The younger the child, the worse the prognosis. The virulence of the infection is, of course, of prime importance, and this varies greatly in different instances. I have seen children go through an attack of infectious diarrhea with only mild discomfort and very little fever; others may be doomed from the start, and may die in a very few days. The mortality is always high, especially the hospital mortality, among the poorer classes; but so much depends upon the factors given above that it is impossible to give exact figures that mean anything.

PROPHYLAXIS OF DIARRHEAL DISEASES

No raw fruit or vegetables should be given to children under five years of age, and care should be taken that all food ingested be in a finely divided form. Overfeeding should be carefully avoided in hot weather, especially overfeeding with sugar. It is always good practice during a hot spell to dilute the baby's milk one-third with water. Overclothing the baby is also to be avoided, and frequent bathing, avoidance of the sun, and providing him with water to drink between his feedings are all important. In the southern part of this country, during the summer, all milk fed to babies, no matter how clean it is, should be boiled. An ounce of orange juice daily will prevent scurvy.

In cooler parts of the country, during the hot weather, all milk should be boiled with the exception of certified milk, which can be given raw; but during very hot, sultry spells this should be boiled also.

There is really no valid argument against using boiled milk in the summer time. The only possible harm it can do is to produce scurvy. But we know that comparatively few babies

who are fed on fresh boiled milk develop scurvy, and orange juice is practically certain as a prophylactic. Undoubtedly nature intended babies to have raw milk, but the dangers of unclean raw milk so greatly outweigh those of boiled milk, especially in the summer, that more and more physicians are ordering boiled milk as a routine, and it is the duty of us all to educate the laity as to the dangers of raw milk in hot weather.

CHAPTER XIII

CHRONIC INTESTINAL INDIGESTION IN OLDER CHILDREN

(*Synonyms: Celiac Disease, Intestinal Infantilism*)

Definition.—A chronic condition seen in children usually from the end of the first to the third or fourth year, characterized by putrefaction or fermentation of the intestinal contents, resulting in foul, undigested stools, and followed in severe cases by extreme impairment of nutrition.

Etiology.—It is all too commonly believed that as soon as a baby has reached the end of his first year, and is on a mixed diet, his liability to digestive troubles is over, and he can eat indiscriminately. It is this belief, this overfeeding, either qualitatively or quantitatively, that is often responsible for chronic intestinal indigestion, a condition very common in its milder, and not at all uncommon in its severe, forms. The present extreme of overfeeding young babies with a mixed diet is not sound, and causes much trouble. While it is probably true that a baby needs some food in addition to milk after he has reached the eighth or ninth month, it is too often forgotten that his digestive tract is not ready for *large* amounts of solid food. Chronic intestinal indigestion usually has its origin during the second year, when the baby is beginning to take many new articles of diet, and there can be no question that a very large proportion of cases are due to the too early use of too much and too varied solid food. The baby's digestive tract develops slowly, he has few teeth, and the few that he has he does not know how to use, so that the proper preparation of the food by the mouth, which is so important with any other diet than a liquid one, often means little, even if the baby has

a full set of teeth. Overfeeding with starch and vegetables, especially potato, is a particularly common cause. Other cases begin with an acute fermentative or infectious diarrhea, the tolerance for food is lowered, too much food is fed, and chronic intestinal indigestion results. The condition may also occur in babies who have had considerable trouble with feeding during the first year of life, particularly those who have had an incapacity for fat. We know comparatively little of the exact processes which go on in chronic intestinal indigestion, but the following conception is one which serves as a good working hypothesis: There is probably a chronic infection of the contents of the intestine with bacteria which should not be there; this produces a continual fermentation or putrefaction of the food before it has had a chance to be digested, the irritating products of which may cause a chronic inflammatory condition of the mucous membrane of the bowel. The poor absorption of food (salts as well as organic material) which naturally follows, plus the absorption of certainly a portion of the toxic substances which have been formed in the bowel, results in severe malnutrition and arrested development. The reason why there is a bacterial overgrowth in the intestine is that so much undigested food residue is present that bacteria flourish at all levels of the intestine, and when once they have gained a foothold, are hard to get rid of. There is probably little deficiency of the digestive juices in most cases. The small intestine should be relatively free from bacteria, and in it are carried on some of the most complicated and delicate chemical reactions that occur in the human body. When this locus is infected with bacteria, and the food is being attacked by them before it can be broken down in the normal way by the digestive juices and absorbed, it is easy to see what chaos may result, and how the orderly processes of digestion and assimilation may be interfered with.

According to Herter[1] the Bacillus bifidus is very frequently found in abnormally large numbers, and he asserts that a very striking fact about many cases is that the bacterial flora of the

[1] Intestinal Infantilism, New York, 1908.

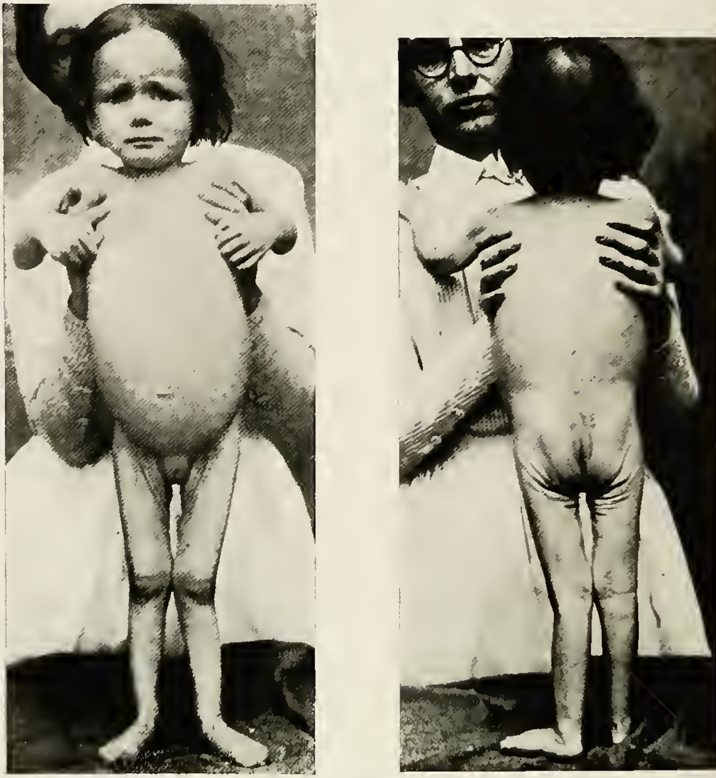
intestine reverts to the early infantile form seen in the breast-fed baby. An overgrowth of the "gas bacillus" (Bacillus aërogenes capsulatus) in the intestine is not infrequently found, and marked improvement is seen when it has been reduced in numbers by a suitable lactic acid milk diet. According to Sylvester[1] the gas bacillus is frequently found in stools of normal children over three years of age, but when it occurs in younger children it is almost always responsible for symptoms of indigestion.

The essential changes in the metabolism consist in a diminished absorption of all the food elements, especially fat. The absorption of this element is practically always poor, and may vary from 60 to 85 per cent. There is also a very poor retention of calcium and of magnesium, and there may be an actually negative balance (Herter).

Symptoms.—The most striking part of the general symptomatology is the interference with the general nutrition, which may be extreme, and is analogous to "marasmus" in younger babies. Not only is the child extremely thin, but he is much underdeveloped in every way, so much so that Herter has given the name of "intestinal infantilism" to the condition. A child of three years may weigh only 17 or 18 pounds and be so weak that he cannot walk. The face is drawn and sharp, the hair usually scanty, and the teeth often poor. Some cases will, however, have perfect teeth, which is rather striking, considering the general poor nutrition and development. The reason for this is that most of the temporary teeth have been calcified before the nutritional disturbance has made its appearance. The bones are very small and frail; this is particularly noticeable, of course, in the arms and legs, which may be mere pipestems. The most striking thing in the appearance is the very large size of the abdomen in relation to the size of the chest. It may in some cases be enormous (see plate), and it is not at all uncommon to mistake the condition for tubercular peritonitis on this account. The large size of the abdomen is due to gaseous dilatation of the atonic intestines which easily push the thin and

[1] Boston Med. and Surg. Jour., vol. clxxxiii, No. 9, 1920.

flabby abdominal muscles outward. It is not at all uncommon to find shifting dulness, which is partly due to liquid feces shifting about in the bowel, and also sometimes to free fluid in the abdominal cavity. The liver may be considerably enlarged, the spleen occasionally. There is the general enlargement of



Figs. 6 and 7.—Chronic intestinal indigestion.

superficial lymph-nodes which so often goes with malnutrition in infancy and childhood. A secondary anemia is common, and a good many of these children have an associated rickets or may show no signs of it. They are often extremely nervous and irritable, and have a peculiar, fretful cry. There is often a fever of slight degree. Despite the fact that the rest of the body

has developed so poorly, the development of the brain is usually little interfered with, and the mind is likely to be quick and active. although the disposition is peevish. The stools are always very foul, and in a hospital ward it is usually possible to pick out a case of chronic intestinal indigestion by the aroma which hangs about the bed. The stools may be formed and constipated, of a light color and rather clayey consistency, or there may be periods in which they are loose and mushy, with large amounts of mucus. They may contain a large excess of fat or of starch, depending upon the type of case, and may be acid or alkaline, according to the kind of food that is being decomposed. The appetite is usually good, and in most cases there is no vomiting. The urine very frequently contains an excess of indican.

Diagnosis.—In the ordinary case the diagnosis is not at all difficult. The history, the appearance of the child, and the character of the stools are all of importance. It is, of course, necessary to rule out any other wasting disease. Tuberculosis is the most important in this connection, and many cases are sent to the Children's Hospital each year with the diagnosis of tubercular peritonitis. In some instances the differential diagnosis between chronic intestinal indigestion and tubercular peritonitis may be extremely difficult, and I can well remember several cases in which the wrong diagnosis was made after we had had the opportunity of studying the child in the wards for a considerable period. In the typical case of tubercular peritonitis of the ascitic type, with a large amount of fluid in the abdomen, there is no difficulty; it is the borderline cases, with a small amount of fluid, which are difficult. The table on page 326 will perhaps show as well as anything the points of difference.

Treatment is difficult, but with persistence good results may be obtained. *It is almost entirely dietetic, and the principle is to adapt the diet to the child in such a way that the particular type of bacterium with which the intestinal contents is infected will have no unabsorbed food upon which to grow.* This depends upon

	Chronic Intestinal Indigestion.	*Tubercular Peritonitis.*
Temperature:	Usually not much elevated.	Considerable irregular fever.
von Pirquet:	Negative under two years. Positive or negative after this.	Usually positive.
Stools:	Much evidence of indigestion.	Not so much evidence of indigestion.
History:	Suggestive.	History of exposure important.
x-Ray:	No tuberculosis elsewhere.	May show tubercular tracheobronchial lymph-nodes or lung.
Abdominal wall:	Thin and very flaccid.	Thick and doughy.
Mesenteric lymph-nodes:	Usually no striking enlargement.	Often many easily palpable glands.

the fundamental truth first recognized by Escherich, that it is possible by a regulation of the type of food to regulate the type of intestinal flora. The first step is to determine whether the intolerance is chiefly for fat or for starch, or for both. Some cases will have an intolerance for sugar, but fat and starch are by far the most common causes of the trouble. The determination of what element or elements are not being digested is of vital importance, and must be accomplished before intelligent treatment can be begun. Stool examination is here essential. Many times the distinction is quite clear, and the child may be able to handle a considerable amount of fat and no starch, or vice versa, but often and, indeed, in most cases the digestive power for both fat and starch is considerably lowered. The stools of a starch case are usually large and loose, of mushy consistency, with many little gelatinous masses of undigested starch and cellulose, of a fermented "pig-pen" odor, and show under the microscope when stained with Lugol's solution innumerable small masses of black undigested starch. In the pure fat cases they are likely to be more smooth and sticky, of a light color, and a foul smell, and under the microscope, when treated with acetic acid and soudan III, many fat globules are seen. If sugar is at fault and the other elements are not, there may or may not be an excess of fat or of starch under the micro-

scope, but the stool will be loose and spongy, with an excessively acid reaction and a sour smell. Protein very rarely causes trouble, and in most cases of chronic intestinal indigestion is tolerated in large amounts.

We have, then, broadly speaking, four types to consider as regards treatment:

1. Essentially fat.
2. Essentially starch.
3. Essentially sugar (relatively uncommon in older children).
4. Mixed starch and fat (most common type).

The principle of treatment is to regulate the diet in such a way that the offending element will be reduced to a minimum, so that whatever organism or organisms are flourishing upon it will be starved out, having no suitable pabulum upon which to grow. The calories withdrawn by the withdrawal of this element are replaced by other substances which are non-fermentable by the particular intestinal flora one is dealing with.

In planning the diets it is necessary to write down everything in exact amounts; it is never sufficient to give verbal directions or to leave any leeway in amounts. I use for this purpose cards, about 8 x 5 inches, which are very convenient, and which can be tacked up in the kitchen or pantry, so that no mistakes will be made (see Chapter VIII).

The food must be regarded as medicine and must be given as such. Nothing whatever can be given except what is on the diet list. The diet must be arranged as carefully and adhered to as closely as that of a severe diabetic would be. It is always well to calculate the calories, and it is often helpful to know the number of grams of each food element that the child is taking. Calories in connection with chronic intestinal indigestion are often misleading, as these children always need a good many more calories per kilogram of body weight than a normal child of the same age does, and it would therefore be useless to attempt to follow any set rule for the number of calories needed by children of different ages, or to follow the normal standard, except in a very general way.

TABLE OF FOOD VALUES (FROM THE CHILDREN'S HOSPITAL, BOSTON. PREPARED BY DR. J. L. MORSE)

	Calories.	Grams: F.	Grams: C.	Grams: P.
Whole milk, 1 quart	670	38	43	34
Skimmed milk, 1 quart	400	10	43	35
Gravity cream, 1 pint	860	77	22	14
Buttermilk, 1 quart	360	5	43	35
Whey, 1 quart	260	5	43	9
Beef juice, 1 ounce	10	[6]		2
Crackers, 1 ounce[1]	120	3	20	3
Bread, 1 slice[2]	75	[6]	15	3
Zwieback, 1 slice[3]	120	3	20	3
Shredded wheat biscuit	105	[6]	22	3
Rolled oats (cooked), 1 tablespoonful[4]	35	[6]	6.5	1.5
Cream of wheat, Ralston, and similar cereals (cooked), 1 tablespoonful[4]	40		8.5	1.5
Potato, size of large egg[4]	70		15	2
Macaroni (cooked), 1 tablespoonful	30	[6]	5	1
Egg: Whole	72	5		7
Egg: Yolk	60	5		4
Egg: White	12			3
Meat (cooked), 1 ounce[5]				
Fish	60	3		7
Bacon, 1 slice = ½ ounce	90	9		1.5
Butter, 1¼-inch cube = 1 ounce	225	24		
Olive oil, 1 tablespoonful	125	14		
American cheese, 1¼-inch cube = 1 ounce	130	10.5		8.5
Cream cheese, 1⅛-inch cube = 1 ounce	130	10.5		8.5
Sugar: cane-, 1 rounded teaspoonful	25		6	
Sugar: milk-, 1 rounded tablespoonful	60		15	
Green peas, Lima beans (cooked), 1 tablespoonful[4]	40		7	3
Carrots, Squash, Turnip, Beets, Onions (cooked), 1 tablespoonful[4]	30		6	1
Orange, medium sized	50		13	
Apple, medium sized	70		17	
Banana	115	1	24	2
Prunes, 4 without sugar	30		7	

[1] Crackers vary so much in size that they must be weighed to determine how many it takes to weigh an ounce.

[2] Bread, 1 slice 4 inches square and ⅜ inch thick = 1 ounce.

[3] Zwieback, 1 slice = large slice.

The following table by Holt and Fales[1] shows the caloric requirements of *normal* children of different ages:

TOTAL CALORIES

Age, years.	Average weight, pounds.	Boys.	Girls.
1	22	950	940
2	27	1135	1110
3	32	1275	1230
4	36	1380	1300
5	40	1490	1410
6	44	1600	1520

Articles of Food Used.—*Milk* soured by the lactic acid bacillus is almost always to be used in preference to sweet milk. Ordinary buttermilk may be employed, or, still better, it may be made from one of the cultures of lactic acid bacilli which are on the market. By flooding the intestine with lactic acid bacilli the growth of saprophytic organisms is inhibited, and children with chronic intestinal indigestion almost always do better on lactic acid milk than they do on ordinary milk. Whereas with the normal child of from one to three or four years of age it is not ordinarily desirable to give more than 24 to 32 ounces of milk a day, in children with chronic intestinal indigestion it is often advisable to give considerably more than this of the lactic acid milk, and many children may take as much as 50 ounces a day with benefit. In the beginning they usually do not like it, but it is rare to find any child who will not take

[1] Amer. Jour. Dis. Chil., vol. 21, January, 1921.

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[4] A tablespoonful means as in ordinary serving, not level.

[5] The lean of a lamb chop weighs about an ounce; so does a piece of meat about $1\frac{1}{4}$-inch cube or a thin slice of beef.

[6] These foods contain from $\frac{1}{4}$ to $\frac{1}{2}$ gram of fat in each of the quantities given.

Clear soups and broths made without rice or barley have practically no nutritive value.

The nutritive value of the "fodder" vegetables, such as spinach, string beans, asparagus, lettuce, celery, cauliflower, cabbage, eggplant, tomatoes, and cucumbers, is so slight that they may be disregarded.

Pears and peaches have about the same value as apples of the same size.

it after a few days, although it may be necessary to withdraw all other food for a day or two until the child gets so hungry that he is glad to take anything. Not more than 2 per cent. of fat should ever be used in lactic acid milk, as preparations containing more than this are too thick. A few ounces of sweet milk may be allowed each day for use on the cereal taken, if cereal is allowed, but the cornerstone of the diet should be lactic acid milk. In cases with an intolerance for sugar it may be necessary to use a milk with even less sugar in it than there is in lactic acid milk. For these cases Finkelstein's protein milk or some modification of it is indicated. If lactic acid milk or protein milk is not well borne, boiled fat-free milk is used.

Starch.—The hardest form of starch to digest is potato starch, and potato in any form should never be given to these children, whether the case be one of fat or of starch indigestion, or a combination of the two. Rice jelly, barley jelly, farina, dry toast, or zwieback are the best forms of starch to use. Zwieback and rice jelly are probably the most digestible.

Fat.—In the fat cases a fat-free milk must be used over a long period of time, and sometimes even the fat contained in the yolk of an egg will cause an upset. In the starch or in the mixed cases a 2 per cent. fat will usually be tolerated. Sometimes olive oil is well borne when butter fat is not, and a tablespoonful of this two or three times a day is often of considerable value. A tablespoonful of olive oil weighs 14 grams, and furnishes 125 calories. In some cases homogenization of the olive oil with lactic acid milk works remarkably well, and is worth a trial if fat cannot be tolerated in any other form, and if the tolerance for the other food elements is low.

It may be necessary in severe cases to keep the child on a practically fat-free diet for several months, and when fat is begun it should be added very slowly and in small amounts.

Protein.—For some reason protein is the best borne of all the food elements in cases of chronic intestinal indigestion, *and a diet very high in protein is almost always advisable.* The protein under such conditions is used not only as a tissue

builder but also takes the place of fat or carbohydrate for fuel purposes. Meat is of the utmost value, and is usually well tolerated even in large amounts. While it is ordinarily not desirable to give meat to normal children until they are about two years old, it may be given in considerable amount to children of sixteen or seventeen months old with chronic intestinal indigestion. To older children it may sometimes be given with every meal, especially if the starch tolerance is low, and little or no starch is being taken. It should always be finely scraped, and the child should be taught to chew thoroughly. The white meat of chicken contains less fat than either lamb or beef, and is, therefore, the best meat to use in fat cases.

Eggs in many cases are well borne, in others not. The yolk of an egg contains about 5 grams of fat, and this should be remembered in cases with a severe fat intolerance. Sometimes the white seems to be more indigestible than the yolk, and if this is so, the yolk can be advantageously given alone by hard boiling the egg, separating yolk from white, and grating it into the cereal or meat.

Cottage cheese is often of considerable value, and makes an excellent substitute for butter. It contains about 30 per cent. of protein and 1 per cent. of fat; full cream cheese contains 26 per cent. of protein and 34 per cent. of fat.

Cottage cheese can be easily made at home from skimmed milk. Add two teaspoonfuls of essence of pepsin to 24 ounces of skimmed milk, and let it stand in a warm place for half an hour. Break up the curd with a knife and strain off the whey. Squeeze the curd in a cheese-cloth bag until practically all the whey has been removed. Salt to taste. The resulting product should be slightly moist and granular. It consists of calcium and of casein, and may often be used with a great deal of advantage. A tablespoonful three times a day is not too much to begin with.

Sugar.—In some cases the sugar tolerance is poor, and fermentation results if any sugar is given. In other cases large amounts of sugar may be given without disturbance, and the

caloric value of the diet may be very materially raised in this way. Indeed, sugar in some form is one of the most valuable foods at our command in those cases which have a good sugar tolerance, as it is a very concentrated food of high caloric value, and enables us to give a high caloric diet in an easily absorbable form. Dextrimaltose or corn syrup are the best sugar preparations to use. A level tablespoonful of dextrimaltose may be added to each 8 or 10 ounces of milk, and furnishes about 36 calories. Commercial corn syrup contains dextrins, maltose, and glucose. On account of the different degrees of rapidity with which these carbohydrates are absorbed there is comparatively little chance for fermentation, and therefore this preparation often makes a very valuable addition to the diet, and may be used in suitable cases in large amounts. It was first advocated by Marriott[1] in 1919 in the treatment of athreptic infants, and applies equally well to older children. If 45 c.c. of the corn syrup is mixed with 55 c.c. of water, the resulting mixture contains approximately 50 grams of carbohydrate (Marriott); 20 c.c. of the mixture, containing 10 gm. of carbohydrate, adds a little over 3 per cent. carbohydrate when mixed with a 10-ounce feeding of milk. I happen to be treating now a most difficult case of chronic starch indigestion in a girl three years old, and nearly one-half of her 1400 calories is furnished by the 150 gm. of carbohydrate which she takes each day in the form of corn syrup. The use of large amounts of corn syrup applies especially to severe starch cases, in which it is extremely difficult to keep up the caloric value of the diet after all or nearly all of the starch has been omitted.

Vegetables.—Our aim in treating chronic intestinal indigestion is to furnish a diet of easily digestible, concentrated food with as high a caloric value as possible. Green vegetables are of such slight caloric value that they are not of much use in the diets of these cases as far as their caloric content is concerned, and, indeed, many children with starch indigestion will become upset on account of the cellulose that vegetables contain. It

[1] Jour. Amer. Med. Assoc., vol. 73, No. 16, 1919.

is well to give a small amount of a vegetable purée every day, however, in many cases. Spinach and carrots are the best vegetables to use, as they contain a relatively large iron content. It must be remembered, however, that it is often necessary to feed these children on very peculiar diets, which may differ considerably from our ideas of a well-balanced diet for a normal child, and in all severe cases vegetables must be withheld, notwithstanding their theoretic value as iron and vitamin containers.

Fruit.—A normal child of two or three years would take orange juice in the morning and probably apple-sauce or prune-sauce with his evening meal. Fruit should, however, usually not be given in any form to cases of chronic intestinal indigestion, as it has a very small caloric value, and is too irritating to the intestine, which we wish to protect in every way possible. There is practically no danger of scurvy.

The following diets show in a general way what might be given to children with various types of indigestion:

Diet I

For a Baby 2½ Years Old, Weighing 18 Pounds, with Severe Fat Indigestion

Breakfast	
7 A. M..	10 ounces fat-free lactic acid milk.
	Dextrimaltose, 1 level tablespoonful.
	Dry bread, 1 slice.
Lunch	
11 A. M.:	10 ounces fat-free lactic acid milk.
	Dextrimaltose, 1 level tablespoonful.
Dinner	
2 P. M.:	Meat, 2 rounded tablespoons.
	Thick spinach purée, 1 rounded tablespoonful (?).
	Custard, 1 small cupful.
	Fat-free lactic acid milk, 5 ounces.
	Dextrimaltose, 1 level teaspoonful.
Supper	
6 P. M.:	3 small zwieback.
	Fat-free sweet milk, 3 ounces.
	Fat-free lactic acid milk, 8 ounces.
	Dextrimaltose, 1 level tablespoonful.
9 or 10 P. M.:	Fat-free lactic acid milk, 10 ounces.
	Dextrimaltose, 1 level tablespoonful.

Total calories, about 1050. About 57 calories per pound.

Starch.—In many cases of starch indigestion a certain amount of starch may be allowed, under which conditions the diet is not hard to plan. In the most severe cases it is necessary, however, to omit all starch, which makes the planning of the diet rather difficult. I will always remember one extremely severe case of combined starch and fat indigestion, a girl four years old, who had been treated over a period of two years by three or four of us without much success. She would do well for a while, then would have a severe relapse, and lose all the weight she had gained. She weighed at four years less than 25 pounds, and was in miserable condition. All of us who had treated her previously had kept the fat and starch in her diet low, but had never omitted starch entirely. The next man who tried her omitted all starch, and fed her nothing whatever but lactic acid milk, skimmed milk, corn syrup, and meat, allowing very large amounts of lactic acid milk and meat especially. Her diet consisted, therefore, entirely of protein and sugars. The result was little short of miraculous. She gained several pounds in a few months, her progress was steady, and in about six months she was a strong, healthy child. The explanation of the good results in this case is probably that her intestine was infected with some organism or organisms which flourished upon starch, and as long as there was even a small amount of starch present it was enough to keep the organism alive, and thus to allow a certain amount of fermentation to be continually present. The entire withdrawal of starch from the diet over a considerable period of time caused the organism to slowly die out, as it had no food to grow upon. This principle of feeding no starch whatever is of the utmost importance, and should be used in all severe starch cases.[1]

[1] If it is necessary to omit all starch, biscuits or bread made from one of the casein flour preparations which are so commonly used by diabetics make often a most welcome and valuable addition to the diet.

Diet II

For a Moderately Severe Starch Case. Age 2½ Years. Weight 20 Pounds

Breakfast
7 A. M.: 2 per cent. (fat) lactic acid milk, 8 ounces.
Dextrimaltose, 1 level tablespoonful
Farina, 2 tablespoonsful.
Sweet milk, 2 ounces.
1 egg.

Lunch
11 A. M.. 2 per cent. lactic acid milk, 10 ounces.
Dextrimaltose, 1 level tablespoonful.

Dinner
2 P. M.. Meat, 2 rounded tablespoonsful.
Spinach purée, 1 tablespoonful (?).
Yolk of 1 hard-boiled egg.
2 per cent. lactic acid milk, 8 ounces.
Dextrimaltose, 1 level tablespoonful.

Supper
6 P. M.: 2 large zwieback.
Cream cheese, 1⅛-inch cube.
2 per cent. lactic acid milk, 10 ounces.
Dextrimaltose, 1 level tablespoonful.

9 to 10 P. M.: 2 per cent. lactic acid.
Milk, 8 ounces.
Dextrimaltose, 1 level tablespoonful.

Total calories, 1385; 69 calories per pound.

Diet III

For a Very Severe Combined Fat and Starch Case, Three Years Old. Weight 19 Pounds (Actual Diet Now Being Given to Baby A. B.)[1]

Breakfast
7 A. M.: 1 per cent. (fat) lactic acid milk, 8 to 10 ounces.
Corn syrup mixture, 60 c.c. = 30 gm. carbohydrate.
Scraped chicken, 1 rounded tablespoonful.

Lunch
11 A. M.: 1 per cent. lactic acid milk, 8 to 10 ounces.
Corn syrup mixture, 60 c.c.

Dinner
2 P. M.: Scraped chicken, 1 rounded tablespoonful.
1 per cent. lactic acid milk, 8 to 10 ounces.
Corn syrup mixture, 60 c.c.

[1] This type of diet, containing no starch whatever, is of the utmost value in severe starch cases, and gives better results than any other.

Supper

6 P. M.: Scraped chicken, 1 rounded tablespoonful.
1 per cent. lactic acid milk, 8 to 10 ounces.
Corn syrup mixture, 60 c.c.

10 P. M.: 1 per cent. lactic acid milk, 8 to 10 ounces.
Corn syrup mixture, 60 c.c.
Total calories, 1350 (approx.); 61 calories per pound.

These diets are intended to serve only as a general guide, and would naturally have to be modified to suit the individual case. As will be noted, they are all high calorie diets, and represent the upper limit which a child could take, rather than the lower. It will be also noted that sugar has been used in rather large amounts in each diet. This is desirable, if possible, but often would not be tolerated. In order to get as much food as possible into the child it is often well to use a 9 or 10 P. M. feeding, as shown on the charts. If this is omitted, the caloric value of the diets is, of course, considerably lowered.

Other Measures of Treatment.—Artificial digestants, such as pepsin and hydrochloric acid or pancreatin, might be thought, from a theoretic standpoint, to be of service. Practically, they are of little value. The drugs which may be of service are castor oil, bismuth subcarbonate, iron, and tincture of nux vomica. Castor oil is often needed, and it is a good plan in severe cases to give a dose of it as a routine every week or ten days. It should be given especially if the abdomen becomes more distended than usual. Bismuth is of value during a relapse when the stools are frequent and loose. The subcarbonate is the best preparation to use, and can be given in doses of 20 grains three or four times a day. Practically all children with chronic intestinal indigestion are anemic; it is therefore well to give iron as a routine. The saccharated oxid of iron is the most convenient preparation to use, and is given in doses of from 3 to 5 grains three times a day. Tincture of nux vomica in small doses is of value as a general tonic, and as an appetizer, but need not be used as a routine. Needless to say, it should not be given if the child were very nervous.

An intelligent graduate nurse is of the utmost importance if the family has the means to afford one. A good nurse soon gets to know the child so well that she is of inestimable value to the doctor, and these children need some one to care for them who can use her head rather than her heart, which is not the case if the mother does it. Their lives must be run like clockwork, and good results cannot be expected unless an exact daily routine is followed.

It goes without saying that sunshine and fresh air are indispensable. Although it is desirable to have these children out of doors, it is often best to let them out only once a day, in the morning preferably, and to keep them in the house the other half of the day, near a sunny open window. This applies especially to the winter season, and the reason for it is that they are likely to get overtired if they are taken out of doors twice during the day, with the incidental dressing and undressing, going down stairs, etc. A good many severe cases are too weak to walk, in which case they are wheeled when out of doors, and allowed to play on the bed or in a pen when in doors. Even if they can walk they should not be allowed to take very much exercise, as too many calories of their diet are used up in this way. They also get overtired very easily. They do well, as a rule, in summer, and may gain considerable weight, especially if they are at the seashore. There is no place like a sunshiny beach for a sick child, and one of my recent patients with chronic intestinal indigestion spent practically the whole of every day last summer on the beach, with most excellent results. In the winter progress is likely to be slower, and a slight cold or sore throat may bring about a relapse, and undo all the good that has been accomplished by weeks of painstaking care. Massage may be of considerable value in promoting the circulation. Olive oil is, of course, not absorbed to any appreciable extent through the skin, and it therefore makes no difference whether alcohol or olive oil is used for the daily rub.

Course and Prognosis.—The course is long in most cases; it will certainly take many months before the child begins to

even approach the normal. There is no condition which requires more patience on the part of the nurse, the parents, and the doctor, but by persistent effort good results can be obtained. Relapses are inevitable, and are manifested by abdominal distention, rapid loss of weight, possibly vomiting, and very loose, foul movements containing a great deal of mucus. At the onset of a relapse the child should be given a dose of castor oil, put to bed, and be given for a few days nothing but lactic acid milk to eat, with bismuth subcarbonate in large doses. One must not try for rapid gains in weight. If the general condition improves, if the child looks better, feels better, and is obviously stronger, it is well to be satisfied, and not to increase the diet rapidly in the hope of bringing about a rapid increase of weight. After a few weeks of good stools and better general condition the diet can be gradually raised, and finally pushed to the limit. If the child is gaining weight and doing well do not change the diet in any respect whatsoever, no matter what the calories in it may be. With careful treatment the ultimate prognosis is good as to final recovery, although it may take two or three years in bad cases. When the child finally starts to go ahead he often progresses rapidly, and many of these children are eventually as healthy as any other children. They are, of course, especially during periods when they are not doing well, very susceptible to acute respiratory infections, and as a rule bear them poorly.

Milder Cases.—The foregoing applies only to the severe type of case, where there is marked nutritional impairment. There are, however, many relatively mild cases where the nutrition suffers comparatively little, which do not present at all the picture of "intestinal infantilism." A child is brought because "he does not seem well." His appetite is capricious, he is nervous and restless, sleeps poorly, and complains of abdominal discomfort. The stools may be rather loose and foul, in number two or three a day, or they may be constipated, large, and of a light gray color, or may appear perfectly normal. Upon examination the child is found to be somewhat underweight—the flesh is flabby, the face usually pale, or sometimes

somewhat yellowish, with dark circles under the eyes. The tongue is likely to be coated, the breath foul, and the urine may contain an excess of indican. The abdomen is usually distended, but not to the degree that it is in the more severe cases previously described. The liver is likely to be enlarged.

Upon inquiry it will usually be found that the child is being overfed either with starch or with fat. The diagnosis is made from the symptoms, history, careful scrutiny of the diet, and last, but not least, by a microscopic examination of the stools for starch and fat. It is in just this type of case that microscopic stool examination is of especial value, and indicates at once the cause of the trouble. The treatment, in general, is similar to that of the more severe cases, but need not be so radical. If the indigestion is for fat, it is usually sufficient to pour off all the cream from the milk the child is taking, and to omit butter and bacon from the diet. Usually, after a few weeks, fat can again be added. If the indigestion is for starch, the amount of starch in the diet must be considerably reduced, although it is not necessary to omit it entirely, as it is in the more severe cases. It must be remembered that many children from one to three years of age are grossly overfed with starch, taking a large bowl of cereal with bread and butter in the morning, potato at noon, with more bread and butter, and often cereal and possibly bread again at night. It is always advisable in any case of starch indigestion, whether mild or severe, to omit potato entirely, as this is probably the most indigestible form of starch. Zwieback, rice jelly, and farina or barley jelly may be substituted for oatmeal and bread, and it is never well to let children have a large amount of the *same sort* of starch during the day. If oatmeal is taken in the morning, some other cereal, or milk toast, or zwieback should be taken at night. It is especially important to see that all starchy foods are well cooked, and many cases of mild or moderately severe starch indigestion arise from a proper or insufficient cooking. The prognosis in these milder types of indigestion is usually good, and with a little care in the diet the child should soon become well again.

CHAPTER XIV

THE PHYSIOLOGY, CARE, AND FEEDING OF PREMATURE INFANTS

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Definition of Prematurity.—A premature infant, as implied by the name, is an infant not yet fully developed. The name is applied to an infant in every respect normal except that it has been born before it is fully developed in some of the fundamental capacities fitting it for this life. The pregnancy for one reason or another has terminated early and the baby is born in an unripe state. The term "prematurity" is often erroneously used as synonymous with weakness or debility. Prematurity means premature birth and needs no other explanation. Congenital debility, on the other hand, means a deficiency of vital energy and a lowered resistance irrespective of the age. The confusion comes in that at times a premature may be debilitated as well as born too soon. It was well expressed by Tarnier, who said, "Not all premature children are weaklings, and not all weaklings are premature." Hence we may speak of a baby as mature, born at full term; premature, born before full term; immature, a weakling irrespective of age.

That all prematures are feeble as compared to healthy infants born at term must be evident, and it is a great mistake to judge a premature by the development of the full-term infant as a standard for normal. The premature may or may not be normal for his own age, but what is normal for seven months is abnormal for eight months as well as for full term. One might say that a premature is an unripe individual, and for that reason

unprepared for the difficulties of the life of the full-term baby. A knowledge of the reason of the early birth and of the degree of the unripeness is essential, for in the recognition of his unfitness lies the cure for the treatment of a premature. It is unwise to be too sanguine as to the general appearance of a premature. If an infant is born before term it is unripe, unfit, and must be treated according to its age. The old idea that a baby born at seven months has a better chance than one born at eight months is wrong. The eight months' premature looks like a full-term infant and is, in consequence, given care without consideration of his deficiencies. Of course, the earlier born, the greater the difficulties in treatment, but if there is any question as to the length of the pregnancy, treat the baby as a premature, if only for a few days, regardless of its appearance of maturity.

Incidence.—The incidence of prematurity varies as reported from different sources, and is estimated as high as 5 to 25 per cent. of all births. The variable figures must depend on the factors causing early births, and are probably more active at one time or place than another. During war or any great social upheaval, with the attendant nervous strain, insufficient nutrition, and the whole disorder of living, the mothers are probably in such condition that they are unable to go to term. During epidemics of infectious diseases the rate of prematurity increases. The greater percentage of premature births mentioned in the winter and spring months as compared to summer and fall is very likely due to infection and unhygienic conditions.

Causes of Prematurity.—Premature interruption of the pregnancy is spontaneous, or induced by reason of obstetric necessity, and the causes leading to the early birth may be grouped under six general heads. These causes are: (1) *External*, as physical exhaustion, lifting, nervous excesses; (2) *trauma*, with rupture of the membranes; (3) *multiple pregnancies;* (4) *faulty nutrition;* (5) *disease in mother and baby* (syphilis); (6) *disease in the mother*, cardiac and kidney, tuberculosis; acute infections, as scarlet fever, influenza, typhoid, measles, pneumonia, and the toxic poisons of alcohol, phosphorus, mercury, and

morphin. Some of these are not only the causes of prematurity, but make for debility as well, so that a baby born before full term of a diseased or enfeebled mother is probably feeble as well as premature, especially if the fetus suffers the infection.

Physiology.—The most troublesome factor in the successful management of a premature is his unstable heat regulation. This is dependent on three reasons: increased radiation, unstable heat regulation, and lowered chemical heat production. The premature radiates heat more easily for two reasons—poor fat pad to conserve heat, and relatively greater radiating surface compared to his cubical contents, which means heating plant. The nervous system is underdeveloped, including the heat center; hence the premature is unable to prevent the loss of heat. It is true that a premature loses heat after birth and has no power to regain it unless heat is supplied artificially; while, on the contrary, a full-term baby loses heat and has the power to regain it. It is equally true that the premature cannot prevent getting overheated if the surroundings are at too high a temperature, which often is as disastrous as chilling. Added to the conservation and regulation of heat is the third reason of unstable temperature, and that is the poor chemical heat production due to low powers of digestion and metabolism. There are at times other reasons given besides the three mentioned, which are unimportant, and, as a matter of fact, are merely slight contributory causes.

The nervous system is quite unstable and the control of the vital nerve centers poor, owing to the fact that some of the nerves are still unmedullated and the nerve centers undeveloped. In consequence of this undeveloped nervous system prematures are sluggish in their reactions: they are somnolent and inactive; their movements are slow, and the cry feeble. They are prone to intracranial disturbances, such as cerebral hemorrhage and hydrocephalus of the oversecretive type, which, fortunately, tends to spontaneous cure.

The heart and circulation show underdevelopment. During the last few weeks of intra-uterine life the ductus arteriosus

narrows, thus aiding its postnatal closure, and also of the foramen ovale. The heart is surprisingly strong and regular in action, but occasionally due to faulty innervation may show weakness and irregular action, with cyanosis and edema. The blood-vessels are fragile and hemorrhage may occur from slight causes.

The blood shows more of the fetal characteristics the earlier the birth. As a rule the coagulability is low, hemoglobin and red cells high, and there are many nucleated cells. The H ion concentration is higher than in normal full-term babies. Behrend showed that in the first few days of life the alkalinity was only 70 to 80 per cent. that of the adult, but increases rapidly with age. Pfaundler attributes the greater susceptibility to infection to the high H ion concentration, as it has been shown that diminished H ion concentration gives greater resistance to bacterial invasion. It is proper to mention here that there may be another reason for increased susceptibility to infection in the lack of antibodies received into the blood from the mother. Prematures early become anemic on account of their poor blood-making power, the greater blood destruction, and the deficient supply of iron.

The respiratory system shows marked lack of nervous control. The breathing is shallow and irregular, and there may be long pauses when no apparent air exchange takes place. As a result of the unstable nervous control expansion of the lungs is poor, atelectasis is common, and metabolism cannot be perfect. There may be frequent attacks of cyanosis, rapid breathing, and asphyxia, and such an attack may be fatal at any time during the early weeks of life though the baby seems to be doing well. These attacks are variously explained. Finkelstein believes they are caused by carbonic acid intoxication aided by insufficient lung expansion due to abdominal distention. Budin says they are due to underfeeding and disappear with forced feeding. Other writers think they are due to cerebral disturbance, pulmonary atelectasis, or aspiration of milk into the trachea, and that owing to poor reflex action the babies are unable to cough

out the food. I have seen several with cyanosis and rapid breathing due to enlarged thymus. At all events there must be several causes for such attacks, and obviously the treatment depends on the cause.

It is natural that the digestive tract should share in the lack of development. The very young prematures often do not know how to suck or swallow, and older ones may know how, but soon tire. Not only is the mechanical part of the work deficient, but the chemical as well. The digestive juices are quantitatively and qualitatively low. They can take care of all of the food elements, including starch, to a limited degree. The digestion is weak, yet the premature needs more food than older infants to give him the required fuel, to make up for the unstable heat regulation, and to supply the materials for more rapid growth. The caloric requirements are variously estimated at from 120 to 180 calories or even higher per kilo. The lowest figures are much above those given as sufficient for a full-term baby. Oberwarth found that the average quantity of milk taken by 33 prematures at fifty-one different nursing periods during three months was 63 calories per pound. It is stated that an infant needs one-sixth of its body weight in fluid per day. These figures for food and fluid are impossible to get in the first few days, but must be approached as soon as possible, especially as regards fluid, in order to prevent the storing up of waste products and, hence, inanition fever. These babies are poor nursers, and if by chance strong enough to go to the breast, they must be watched to see that they get sufficient food and fluid. If the breast secretes well, they may be overfed, but, as a rule, they are so feeble that to get enough it may be necessary to put a strong baby to the other breast at the same time or express milk while nursing. The initial loss of weight should be relatively less than of the full term, as there is less meconium and food and fluids are started earlier. On the other hand, the gain is slower—an average of ½ ounce daily and 4 ounces a week is satisfactory.

Though the kidneys begin to function in the late fetal months, they do so rather imperfectly. In consequence of the poor

kidney action and the insufficient intake of fluid the urine is scanty, the acidity high, and there may be enough uric acid to cause infarction, with temporary suppression. The proportion of ammonia nitrogen to total nitrogen is less than the normal, while the non-protein nitrogen is increased, indicating an increase in the decomposition processes.

Resistance to infection is poor and infections, no matter where the portal of entry, are likely to be severe or at least more severe than in older babies with the same type of disease, and may run a course with high or low temperature. There is a virulent, hemorrhagic form of pneumonia which runs an afebrile course. It is not possible to rule out an infectious process in a premature because of a low temperature. This low resistance has been explained, as mentioned above, on the grounds of the higher H ion concentration of the blood.

The weight of the premature depends on the age and the cause of the early birth. As there are factors outside of the age which have a bearing on the weight, the age cannot be determined from the weight alone. From the figures of Berthod, 48 babies born at eight months or more, including 7 at term, the average weight was 4½ pounds; 52 born at eight months or less, including 2 at six months, the average was the same, 4½ pounds. The weight varies from 2 to 5½ pounds, hence, if under 5 pounds and not puny, an infant is probably premature. Naturally, if born of a healthy mother and not born early by reason of disease, the baby will be heavier than one of the same age born of a diseased or enfeebled mother.

The development of the skeleton gives some evidence not only in its measurements but also from roentgenograms of the centers of ossification. During the late months of intra-uterine life the lower extremities grow rapidly as compared to the upper half of the total length. The premature is short, especially in the lower extremities, as compared to the upper half, giving a total length of 19 inches or under. The circumference of the head is always greater than that of the chest. There have been tables worked out giving measurements for different ages and

weights, but for all practical purposes a baby of 19 inches or less is presumably premature.

The skin is red, wrinkled, as there is very little subcutaneous fat, covered with lanugo hairs, dries and macerates easily. The ears lie as tabs close to the head. The nails may be absent or, if present, thin and fall short of the ends of the fingers. Icterus neonatorum is usually well marked and may be slow in clearing. Feeble prematures not uncommonly show sclerema.

Prematures are poorly supplied with mineral salts (especially iron) which are stored up in the late weeks of intra-uterine life. Hugounenq's analyses indicate that twice as much mineral salts are stored up in the last three months as in the first six. Hence it would appear that the more premature the birth, the less salts and iron the infant will have, and, of course, the earlier will the stock be exhausted. It is true that premature babies show anemia and rickets much earlier than full-term babies. Huenekens found definite rickets in 27 of 33 prematures seen for the first time when four months of age, which is earlier than is usually found in normal full-term infants.

We may sum up the characteristics of a premature as follows: he is small, emaciated in the sense that he has no subcutaneous fat; skin red, wrinkled, covered with lanugo hairs, head large compared to the chest, limbs small and puny, nails thin and fall short of the ends of the fingers, cry feeble, torpid and hard to waken, eyes kept closed, respiration superficial and irregular, temperature low, with a tendency to fall and hard to maintain at the normal level, power to suck and swallow diminished or absent.

TREATMENT

General Care.—The fundamental principles of the care of premature babies are plain, and the treatment should be simple and easy to carry out. The whole plan of treatment is based on the endeavor to supply what is lacking and make up for deficiencies. It is made difficult in that often we make our machinery for the care too complicated, depend on mechanical devices to spare brains, whereas the successful result depends upon simple

procedures and simple apparatus watched over by an intelligent, interested, and faithful nurse.

For the purposes of treatment it is important to determine two things about a premature—its probable age and its vigor. All things equal, a vigorous baby of eight months has a better chance than a vigorous one of seven months, but, on the other hand, the older baby, even though somewhat feeble, with care has a better chance than the younger one, for he is more mature and functions better. The age is to be determined from the history of the pregnancy, from the weight, and from the total length. The vigor is to be judged from the weight, temperature behavior, cry, condition of the respiratory apparatus, and other signs of feebleness.

The premature lacks energy, vitality, stability. No matter how strong he may appear, he is to be treated with greater care than a more feeble full-term baby, for he is unripe and unprepared. He has no business to be out in the world, consequently the expert care or, rather, intelligent care should begin with the first breath. Many prematures have been lost for lack of care in the period after delivery when received in a cold blanket, and tucked away anywhere to be out of the way until a more convenient time arrives to fix them up. In the meantime too much heat has been lost. Heat should be supplied immediately, unnecessary handling prohibited, and no examination made that can be avoided. They should not be transported, but if unavoidable and impossible to keep where born, should be carried in a heated basket protected from cold air. A premature is better kept in any fairly ventilated, warm place than rushed out in the cold or storm to a model hospital. Let him alone, do not handle him when possible to avoid it, and keep all inquisitive persons away, because they may fuss and handle the baby and bring infection.

At the confinement there should be some person delegated to care for the baby, someone having no other duties than to take charge of the baby and start the premature care at the first moment. If it is etherized or not breathing well it may be wise

to keep it in a warm bath until breathing well, and if at any subsequent time the temperature is low in spite of heaters, put the baby in a warm bath until the temperature is up. As soon after birth as is deemed wise oil it, put on a gown, and place it in a suitable bed in a warm place.

I feel that there is no necessity for complicated electrically heated beds and premature rooms. Incubators should be mentioned only to condemn them. Electric pads are dangerous when tucked in the bed under the clothes from the possibility of fire, and from steam if wet. Of course, the fire danger does not apply to beds heated by electricity. My objection to complicated beds is that they are expensive and are unnecessary for ordinary family use, and even in hospitals I have found the ordinary infant crib perfectly satisfactory when dressed in such a way as to make a premature bed.

A workable premature bed can be made out of any large basket or wire infant crib. The sides should be lined by a padding made of silence cloth, such as used on dining tables, or thin blanket covered with cotton sheeting. This padding is carried about the four sides of the bed and under the hair mattress, covered with rubber or stork sheeting. Thus cold air is prevented from coming up about the baby. The bed is then covered head and foot with sheets or curtains which extend over the sides, leaving an air space between the edges of the head and foot curtains about a third of the distance from the head of the bed to the foot. This air space may be narrow or wide, according to the needs of the baby.

The room should be light, airy, and easily ventilated. The premature baby's eyes must be protected from strong light, but that is no reason why the room should not be hygienic. I have been in premature rooms presumably properly constructed as to heat and moisture regulation, but with air so foul that a few minutes stay was enough to give one a headache. The temperature of the room should be as little above 72° F. as possible. However, much higher temperature, even to 80° F., may be required. In the climate of Boston there is no need for concern as

to the moisture, but in dryer climates the humidity must be watched, for the babies do not do well and have dry skin and cracked lips if the humidity is low.

The most troublesome factor in the management of a premature is the heat regulation. As has been mentioned, this is dependent on the lack of the fat pad to conserve heat, increased radiation, and deficient heat supply. The fat pad is supplied by a padded gown, increased radiation is prevented by the gown, heat is supplied by a padded bed, heaters, and warm air to breathe. It may be difficult at first to adjust the arrangements so that the temperature will stay at the normal level of 99° to 99.5° F., though the sooner this is accomplished, the more promising the outcome for the baby.

There are several types of gowns, and all have good points. The simplest pattern is a rectangular body part with a small square fastened at the middle of the top, which, when folded and sewed together along the top edge, makes a hood. A cheap gown is made of cheese-cloth, padded with non-absorbent cotton and quilted. Better gowns are made of eiderdown, which, though more expensive to make, are, as a matter of fat, cheaper in the end, for they can be laundered, whereas the cheap cotton gown must be thrown away when soiled. The body part should be wide enough to wrap about the baby, with plenty to pin, and long enough to turn up and pin. The gown may be fastened together with tapes instead of pins if desired.

As soon after the birth as possible the baby is oiled with sweet oil or mineral oil applied with absorbent cotton rather than with the bare hand, for cotton is softer and less likely to irritate the skin. A shirt should be put on, especially if eiderdown gowns are used, the usual cord dressing applied, and a diaper with a square of absorbent cotton under the buttocks which will stay in place without pinning. The gown is then fastened, and outside of all is wrapped a blanket. This whole bundle—of baby, gown, and blanket—is placed in the premature bed with three hot-water bottles, one on each side and one at the foot. On the front of the blanket wrapped about the baby is laid an ordinary

bath thermometer. Over all—baby, thermometer, and bottles—the ordinary blankets are placed and tucked under the mattress. The best heaters are some form of stone hot-water bottles or jugs. We are able in Boston to get very satisfactory old-fashioned stone hot-water bottles made by the Dorchester Pottery Company. These stoneware heaters are better than rubber or metal bottles, as they radiate heat more slowly and stay hot longer. The water should be distinctly warm to the wrist, a temperature of about 115° to 120° F. The heaters should never be changed all at one time, but in rotation, thus endeavoring to maintain a uniform temperature.

The bath thermometer on the outside of the wrapping blanket and under the covering blanket is the guide to the management of the bed heaters, ventilation, and room temperature. The rectal temperature should be taken every four hours for the first three days, or until the baby's temperature runs at the normal level of 99° F., or, better, a little above, and it is nearly impossible to obtain good results with feeding unless the temperature runs properly. Frequent readings of the bath thermometer ought to be made to observe what temperature it records when the baby is normal. This is the guide—the temperature of the bath thermometer—as to the temperature of the room and the heaters, which should be kept at whatever temperature is necessary to keep the bath thermometer at the established point. A good starting-point for the bath thermometer is 85° F., which is to be lowered or raised according to the needs of the baby by more or less frequent changing of the heaters or varying the temperature of the room. I think it will be obvious that the arrangement of the bed thermometer gives a convenient indicator as to the proper temperature without disturbing the baby more than twice a day for a temperature taking.

The baby is not to be handled or in any way disturbed more than is absolutely necessary. The gown is opened twice daily after the first three days or after the period of four-hour temperatures, when the diaper is changed and a rectal temperature

taken. At other times it is only necessary to remove the absorbent cotton square unless the diaper is wet. Every third day the baby is to be taken out of the gown, oiled, weighed, and a fresh gown put on. Once a day the face and buttocks should be washed with soap and water, and, as a rule, no other bathing until the baby is out of premature care. Occasionally a baby with tender skin cannot stand oiling and a heavy gown, and the axillary regions will become macerated. This necessitates the use of powder and a thin gown, in which case the surroundings must be at a higher temperature.

Feeding.—In a choice of foods breast milk stands alone. The older babies do better with breast milk, the young, feeble ones *must* have it, at least in part. The problem of feeding is simple if there is a good supply of breast milk, and then it is only a matter of how to get the food in, the quantity at each feeding, and the intervals between feedings. I think a safe rule to follow is never to put a supposed premature to the breast unless it is vigorous, and not until a few days have elapsed, in order to judge of his vitality, and even then with caution for fear of overtiring. Prematures are not strong enough nursers to stimulate the breast. They may for a short time pull well, and it is sometimes surprising how vigorously a little premature will pull on the breast. I have seen a feeble premature pull the nipple into a nipple shield, but they must be watched, as the exhaustion can easily more than make up for the amount of milk obtained, and failure to gain be due to overexertion at nursing. However, underfeeding is not the only danger in breast feeding, but, on the contrary, there is the danger of overfeeding if the milk flows abundantly. The nerve reactions of a premature are feeble and he does not know when he has had enough, and must, of necessity, regurgitate when overfull. Vomiting or regurgitation are signs of danger in feeding prematures, which must never be ignored whether the feeding is natural or artificial. Regurgitation is the first sign of indigestion, and the food must be lowered in quantity or quality, or both.

Fluids should be given a few hours after birth, plain water or

5 per cent. solution of sugar of milk, in teaspoonful doses, increased rapidly by $\frac{1}{2}$ teaspoonfuls till the baby refuses or regurgitates. This will depend on the ability to suck and swallow. Fluids must be given, and if the baby can neither suck nor swallow, he must be tube fed; if he can swallow, use a medicine-dropper, spoon, or Breck feeder; if he can suck and swallow, Breck feeder, bottle, or breast. An ordinary urethral catheter, size No. 12 French, with a small funnel attached either directly into the catheter or by a rubber tube and glass connection (the glass part of a medicine-dropper does well) affords a satisfactory tube for feeding. Introduce the catheter just beyond the pharynx, as manifested by the gagging reflex, or if this not present, to about 4 inches beyond the lips. It is not necessary to push the tube into the stomach. Feed slowly and intermittently by pinching the tube, and do not overfill the stomach. The Breck feeder is made on the plan of a large medicine-dropper with a small nipple on the small end. The glass part holds an ounce and is drawn down at one end to fit into a nipple the size of the rubber of a medicine-dropper, and at the other end is a rubber bulb shaped like a big finger-cot. Pressure can be made on the bulb to aid a baby with feeble sucking power.

There seems to be some difference of opinion as to the interval between feedings. I have no sympathy with the long four-hour interval. Except with a tube I do not see how it can be possible to get in a sufficient amount at each feeding to cover the requirements for the day. I believe with two-hour intervals night and day for the first few days it is easy to get in the total requirement without undue strain on the baby. They will not take much at first and frequent feedings are necessary. As soon as possible I lengthen the interval at night and then in the day. When the weight is 5 pounds and the baby doing well, three-hour day feedings and four-hour night are better, for the total requirements can be met and the baby disturbed less often. I usually begin with 1 dram and increase by $\frac{1}{2}$ dram every feeding or every other feeding until the tolerance is reached. It has seemed to me best to find out the quantity of water or

weak food tolerated first, and then to increase the quality. It is far better to feed a sufficient quantity of weak food than to cause an indigestion with a small quantity of strong food.

I should never consider any other food than breast milk except from necessity. It should be diluted as low as one-third breast milk and two-thirds water, or lime-water, depending on the age and vitality of the individual premature. Increase the strength as rapidly as seems prudent. It is not possible to lay down rules for the routine feeding of prematures any more than can be done for older babies; each must be fed as an individual and his individual needs considered, and the food made to conform to those needs. After the mother's milk comes it is often safe to put the baby to the breast twice a day for a few minutes, gradually increasing the number of nursings until it is entirely breast fed. In the meantime express or pump the mother's breast for the whole or part of the supply for the bottle feedings. This can be done for months, and I have had mothers carry their babies through the entire nursing period on their own drawn breast milk when it was impossible for reason of inability on the part of the mother or baby to nurse at the breast. A little breast milk either nursed or drawn is far better than none.

For artificial food I prefer whey mixtures. A safe starting mixture is 1 per cent. fat, 5 per cent. carbohydrate, 0.50 per cent. whey protein, and 0.25 per cent. casein. Such a mixture is made of $1\frac{1}{4}$ ounces of gravity cream taken from all the cream removed from the top of an ordinary bottle of milk after standing six hours, 10 ounces of whey, $1\frac{1}{2}$ level tablespoonfuls of sugar of milk, boiled water up to 20 ounces. The whey must be heated to 145° F. to kill the rennin, otherwise the casein of the cream will be coagulated and tend to plug the nipple. This mixture can be increased by the addition of cream and whey as desired. It has been my experience that prematures tolerate fat well, but that high sugar foods start carbohydrate fermentation and indigestion with secondary fat intolerance, and that high proteins putrify, causing colic and poor appetite. The

mixtures should be well balanced, with protein enough to cover the requirements and no more, and with fat and carbohydrate to make up food sufficient for gain in weight or to cover the supposed caloric needs. Such mixtures cannot be made of whole milk dilutions. Though some young babies stand whole milk dilutions, my most troublesome feeding cases in young babies and prematures have been those previously fed on mixtures too high in protein with consequent protein putrefaction. When the protein needs cannot be covered by a whey mixture, change to total protein mixtures made after any fashion desired by the attendant. The baby is no longer premature in its feeding problem and can be fed as an older baby.

The time to consider a baby no longer premature is when he can take care of his own temperature. If the temperature runs above normal, supply less heat by removing one or all of the heaters. Next take off the gown, dress in ordinary clothes, and put back the heaters. Finally, dismantle the bed. The gradual change from premature care is brought about by the temperature behavior, and when the temperature remains normal without extra heat, the baby is to be treated as an ordinary baby.

Prognosis.—All figures of prognosis as given are misleading, for the feeble babies are not separated from the true prematures, that is, normal babies born before full term. Hence the prognosis of a premature must depend on what he is and what he does. In general, the younger or earlier the birth, the more uncertain the prognosis. Potel gives the following figures for age:

56 babies born at	$6\frac{1}{2}$ months,	83 per cent. died.
131 babies born at	7 months,	58.1 per cent. died.
53 babies born at	$7\frac{1}{2}$ months,	30.1 per cent. died.
110 babies born at	8 months,	35.5 per cent. died.

The weight comes second. Credé's figures show a very large mortality among the very small babies, which probably include many debilitated ones. His figures are:

$2\frac{1}{2}$ to 3 pounds,	83 per cent. died.
3 to $4\frac{1}{2}$ pounds,	36 per cent. died.
$4\frac{1}{2}$ to $5\frac{1}{2}$ pounds,	11 per cent. died.

The cause of the early birth is very important. If premature by reason of disease, which means debility as well as prematurity, the prognosis is grave in proportion to the debility. Complications of atelectasis, hemorrhage, sclerema, and infections certainly add to the danger and make the prognosis hopeless.

The figures of 144 prematures at the Infants' Hospital may serve to bring out some of the points in support of the early care and of the prognosis. Of the total number when last heard of, 51 were living and well. The remaining 93 died, some lived just long enough to enter the hospital, some died after leaving the hospital, as long as ninety-nine days after birth. Of the 93 that died, 36 died the first day in the hospital. The largest single factor in these 36 was delay in instituting proper early care, and the next factor was loss of heat from transportation. Of the remainder of the 93, or 57 in all, 2 died of congenital syphilis, 2 of congenital heart disease, 10 of pulmonary atelectasis, and 43 of infections, some of these after leaving the hospital. The average weight of the 57 that died was 1659 grams. The average weight of the 51 living was 1864 grams. The smallest of the living was born at six and a half months and weighed 1010 grams, about $2\frac{1}{4}$ pounds.

Naturally, the most important point in the prognosis, if the baby is normal, is the care. I believe the largest single factor in the high mortality of prematures is the failure to begin treatment at the proper time—the moment the baby is born. A normal premature of seven months, kept warm, fed properly, and not handled, has a good chance, and will develop so that at the end of a year he has caught up to a full-term baby of the same age.

CHAPTER XV

CONSTIPATION IN INFANCY

It is normal for a baby fed on cow's milk to be slightly constipated, probably largely on account of the relatively high calcium and casein content of cow's milk. In many cases the constipation may be so great as to be abnormal, and is a great source of worry to the mother, but rarely gets the baby into any serious trouble.

The cause lies usually rather in the food than in the baby, but the relatively thin musculature of the infant's intestine also partly accounts for it. Furthermore, babies who are atonic, anemic, and flabby, usually also have atonic intestines, with sluggish peristalsis. The constipation in these babies usually improves coincident with improvement in nutrition. Underfed babies may be constipated, owing to the fact that the absorption of food is so complete that there is little left to make a fecal residue. Babies fed on whole milk mixtures, with the addition of a small amount of carbohydrate, are more likely to be constipated than those who are taking a food rich in fat and sugar and low in protein. Starch, when it is poorly digested, sometimes tends to make a dry, bulky, constipated stool, provided that it has not fermented. Babies fed on malt sugar preparations containing a high dextrin content are more likely to be constipated than those fed on lactose or on a malt preparation containing more maltose.

Constipation is not pathologic unless the baby goes for more than forty-eight hours without a movement, or unless it is giving him symptoms. If the stools are very large, as in cases of chronic fat indigestion with soapy stools, he may not have strength enough to force them out. If so much of the food is

absorbed that no stimulating products are left behind to promote peristalsis, the stools become very hard, dry, and scybalous, and large amounts may collect in the rectum and lower part of the colon. These become still further dried out, and it may be impossible for the baby to pass the marble-like scybala unless an enema is given to soften them. For constipation such as this laxatives do little good. With scybalous stools there is a good deal of pain on defecation and often slight streaks of blood on the outside of the stool. There is also likely to be considerable abdominal distention owing to the backing up of gas, with symptoms of discomfort from this source. Constipation, unless associated with actual intestinal obstruction, such as intussusception, rarely causes vomiting, nor does it impair the nutrition of the child unless of the fat-soap stool type. It causes more worry to the mother and discomfort to the child than it does serious trouble.

A baby should be trained early to pass his stools at a regular time. The sixth or seventh month is not too early to begin. He is held upon a vessel, with a good support for his back, and a small greased glass rod or a glycerin suppository is inserted in the rectum. This will usually be followed by a stool, and after this procedure has been continued for a week or two, many babies realize that they are expected to make a stool at this time, and will usually do so.

Treatment of Constipation.—*Food.*—A regulation of the food is of the greatest importance. The sugar is the most important element in this connection. If the baby is on a food low in sugar and high in protein, adding lactose and reducing the protein will often accomplish the desired result. Sometimes the addition of 1 or 2 tablespoons of lactose to the day's feeding is all that is necessary, and the slight lactose residue which is not absorbed is fermented, the stimulation of which is just enough to correct the constipation. The use of a liquid malt preparation is almost always followed by good results, and is the most valuable single measure at our command in the treatment of constipation in infants. About 2 table-

spoonfuls a day, added to the day's feeding, is usually enough. If this does not suffice, enough should be used to attain the desired result. In babies over eight months of age the addition of a tablespoonful of strained spinach or carrots to the diet is often productive of good results. A small amount of prune juice or apple-sauce may be used even before this. Orange juice has only very slight if any laxative action in most babies, and can never be relied upon.

Drugs.—In many cases laxative drugs are necessary for a time while the food is being adjusted, and help a good deal, although, of course, they do not cure the condition. Milk of magnesia is probably the best mild laxative for babies, and is the one most generally employed by the laity. A teaspoonful once a day, given in the milk, usually suffices. Another drug which is of value, especially in babies over one year of age, is casafru, a preparation made from the pods of the senna plant. It is very mild in its action, and babies take it readily. A teaspoonful given at bedtime is the usual dose. Castor oil should not be used in the treatment of constipation; it is a cathartic, not a laxative, its after-effects are somewhat constipating, and it should be used only when it is desired to empty the intestine quickly and thoroughly for some special purpose, as in the onset of a diarrhea or an acute infection of any sort.

Suppositories and Enemata.—Suppositories are often of value where the rectum is sluggish, and where the baby needs some such stimulus in order to induce him to go through the motions of having a movement. They are, of course, of no value in constipation due to a sluggish upper intestine. Their continued use is a bad habit, as it is likely to accustom the baby so to them that he will not attempt to have a movement unless one is used. They may in some cases, also, be irritating to the rectum, and they not infrequently cause a proctitis, sometimes of severe degree.

In obstinate cases of constipation the use of enemata is the best method of emptying the bowel, especially when there may be a large fecal mass either low in the colon or in the rectum

so hard and large that it cannot be passed. If the scybala are very hard an oil enema may be necessary, to leave in the rectum over night, and to be followed in the morning by a soapsuds enema.

Enemata made of soapsuds and water are usually sufficient, and it is not necessary or advisable to use anything stronger in babies. I much prefer the large douche bag with a small nozzle to any of the smaller syringes which are so often used, as in order to secure results it is sometimes necessary to give a large amount.

CHAPTER XVI

HABITUAL LOSS OF APPETITE

Habitual loss of appetite is fairly common in babies from six months to a year old, very common in older children, and is often a most annoying and difficult condition to treat. Babies under six months rarely lose their appetites. Let us consider first babies fed on milk exclusively, second, older children who are taking a mixed diet. The ordinary causes of habitual loss of appetite in small babies are:

1. Teething.
2. Overfeeding with fat or sometimes sugar.
3. Beginning rickets or scurvy.
4. Not enough fresh outdoor air.
5. Too frequent feeding.

Many babies eat poorly as soon as they begin to feel the first teeth, particularly the upper ones. There may be nothing noteworthy to see in the mouth except very slight swelling of the gums, and the teeth may not come through for several weeks. The pressing of the nipple against the gums causes just enough discomfort to make the baby disinclined to suck. There is not much to do for loss of appetite connected with teething, except to keep the baby outdoors as much as possible, to try spoon feeding instead of bottle feeding, which is usually not very satisfactory, and to lance the gums if they are very much inflamed, hot, and tender. Many babies who are overfed with fat eat poorly; indeed, loss of appetite is one of the earliest and most important symptoms of beginning fat indigestion. The treatment is to feed the baby on a fat-free milk for two or three weeks, until his appetite returns, when fat may be gradually added again. This is often very efficacious, and a baby will often take twice as much of the fat-free food as he did of the other.

Occasionally an excessive sugar intake will cause loss of appetite, and may be attended with no symptoms of sugar indigestion. Usually cutting down the amount of sugar causes improvement, or sometimes changing the kind of sugar in the modification is of benefit.

Babies with beginning rickets often eat poorly. Fresh air and sunshine, cod-liver oil, and the substitution of beef juice, soups, cereal jellies, and vegetable purées for a part of the milk in the diet helps in most cases. If a latent or subacute scurvy is suspected, orange juice will usually improve the appetite.

Now-a-days most mothers realize the benefit of fresh outdoor air for their babies, but some mothers who have no nursemaids are so busy with household cares that they are able to take the baby out not at all in the morning, and only for a short time in the afternoon. Babies who do not get out much often do not eat well, no matter on what sort of food they are fed. If it is not possible for the mother to get the baby actually out of doors enough, he can be dressed as if to go out and put near an open window, preferably the sunniest one in the house. The present custom in almost all new houses and many apartment houses of having sun porches is a good one as far as the baby is concerned, and I have known babies who have never been taken on the street at all, but who live, eat, and sleep upon the sun porch, with the windows wide open, which is just as good as going outside.

Babies under five or six months of age will usually eat, no matter how often they are fed, but too frequent feeding intervals is a fairly common cause of loss of appetite in older babies. By too frequent intervals I mean any interval of less than three hours, and, indeed, a good many babies after the eighth month do better on the four-hour interval. In increasing the interval between feedings for a baby who has lost his appetite it must be remembered that it is the twenty-four-hour amount he takes which is important, and not the amount at each individual feeding. So that if he takes only a little more at each feeding when fed every four hours than he did while on the three-hour

feeding, the change has done him no good, and he may be actually taking less per day, though more at each individual feeding.

The above are the ordinary causes of loss of appetite in babies under a year old. There are a few babies, however, in whom none of these causes are operative, and who never seem to have any desire whatever for food. They usually are seen in neurotic families. In this type of child the lack of desire for food is constitutional, and they seem to be able to get along on very little. There is nothing in the food that is wrong, no disease of the baby, nothing wrong with the régime; the baby simply does not care about eating. Indeed, the two most marked cases of this sort of loss of appetite that I can recall occurred in families where everything connected with the routine of the babies could not have been improved upon in any way, and still they would not eat satisfactorily, taking only 3 or 4 ounces of milk at some feedings, as much as 6 or 7 ounces rarely, and showing as little inclination for solid food. These babies, as a rule, have no sign of rickets or any sort of indigestion; they are happy and apparently do fairly well on their scanty diets, although they naturally do not weigh as much as babies of the same age who eat well. One of these children I have had the opportunity of following carefully for about three years. She never ate well even when a small baby, and at present eats no better. She is never sick, is not at all subject to colds or infections, and is a perfectly healthy child in every way, except that she is very slender, and rather smaller than other children of her age. Loss of appetite of this sort is very trying to the family and to the doctor, and treatment is not very satisfactory. In the first place, the daily routine of the baby should receive careful scrutiny and, if possible, a competent nurse should be secured, who will have entire charge of the preparation and administration of the food. Four-hour feeding intervals should be used, and if the baby is taking only a small amount at each feeding, as concentrated a food as possible should be given. The baby should be taught to eat from a spoon, and solid food begun as early as possible (any time after the sixth month).

Small amounts of cereal, beef juice, or vegetable juice can be given. Olive oil is a concentrated food which is usually well borne, and a teaspoonful of this can be given three or four times a day. The baby should be out of doors as much as possible and be absolutely free from all excitement. There should never be more than one person in the room with him while he is being fed, and, in general, he should see as few people as possible. Usually it is not well to cater to a baby's tastes, but in this sort of case if any food is found which he likes, and will take well, as much of it should be used as is possible. This sort of loss of appetite is not to be confused with the sort about to be described, which is usually dependent upon poor training, and to generally unstable conditions in the household.

Loss of Appetite in Children from One to Eight Years Old Due to Poor Daily Routine.—One of the commonest sort of cases that a pediatrist sees in his office is the badly brought up, spoiled child, who will not eat enough or the right sort of food. For purposes of discussion, especially as regards treatment, these may be divided into two groups, according to age:

1. From one to four years.
2. From four to seven or eight.

1. A child very frequently does not like solid food, and as each new article of food is begun, such as cereal, vegetables, or eggs, he spits it out. The mother thereupon discontinues that article of food, and tries something else, with the same result, so that finally, at the age of eighteen months or two years, the child is taking nothing but a large quantity of milk, and perhaps one or two other articles of food which he may happen to like, such as toasted cornflakes, graham crackers, or potato. He is flabby and pale, fretful and capricious, and runs the whole family. There should be no question of what a child likes or dislikes when he is beginning to take solid food; he should be made to take everything that is offered, even if his nose has to be held, and it has to be forced down. That is, unless he has an actual idiosyncrasy to some food, and is made sick by it, as some children are with eggs especially.

It is not at all to be wondered at that some children do not at the beginning like solid foods when they are changing from an exclusive milk diet to a mixed one. The solid food is absolutely strange to them, it feels differently in their mouths, they do not know how to chew, and more of an effort is required in swallowing. So no article of food should ever be discontinued simply because the child spits it out the first few times. With persistence, a child can be made to like anything, and it is very important to begin at the beginning, and see that he is trained to eat each new food as it is offered. These likes and dislikes, acquired in babyhood, may be continued into later childhood, and may be the source of a good deal of trouble. I well remember one of my own children who would not at first eat spinach; and it was only after several days of forcing that she grew accustomed to it, and has always after eaten it without any trouble.

The physician usually sees a child such as I have been describing at the age of eighteen months or two years. Treatment is almost always satisfactory if persisted in, although it is not easy, and we frequently have children in the private ward of the Children's Hospital who are sent in with a trained nurse for no other reason than to be taught to eat.

Disease or indigestion of any sort is, of course, first ruled out by physical examination, urine and stool analysis, etc. It is always desirable to secure a skilled children's nurse for these cases if possible, as they very frequently are so used to the mother that they know her like a book, and realize that they can do about as they please with her. A firm, impersonal, well-trained nurse is quite a different proposition, and it is often surprising to see how much better the child eats after the mother has retired in favor of the nurse. If there has been a great deal of milk in the diet this should be reduced to 24 or 32 ounces per day or even less. Overfeeding with milk is a common cause of lack of desire for other food, and it is not well to let any child have over a quart a day. The next essential is to put the child on absolutely regular feeding intervals, every four hours, and to allow nothing whatever between meals. If

he eats nothing at one meal, he gets nothing until the next one. He must be made to see that the nurse's will is stronger than his own, and that she pays no attention to his likes and dislikes. Many times cutting down the amount of milk in the diet, regular feeding hours, and substitution of the nurse for the mother will bring the desired results, but in some cases forcing may be necessary. The child's nose is held and when he opens his mouth to cry the spoon is inserted, the tongue depressed, and he involuntarily swallows a part of the food at any rate. Usually a few day's of this sort of training teaches him that the nurse is not to be trifled with, and, rather than be forced, he will eat peaceably. There was a three-year-old boy in the hospital recently who was so obstinate that each time after he was fed he put his finger down his throat in order to induce vomiting, and vomited everything he had eaten. He was immediately fed again, and the process repeated several times. After a few days of this he began to realize that it was easier to eat than to be fed, and there was no more trouble.

Drugs do no good whatever in these cases; these children are not sick, and it is a question of poor home training, lack of discipline, and individual obstinacy more than anything else.

Poor Appetite in Children from Four to Eight Years of Age. —In older children loss of appetite is more frequently caused by eating between meals than by any other one thing. Lack of fresh air, overexcitement, and getting overtired are also potent causes. The excitable, active child, who is in a hurry to get off to school, in a hurry to get home, in a hurry to get out to play, and who often becomes overtired by trying to keep up with older and stronger playmates, never eats well; he is too much interested in other things. The mother, seeing that he eats little at table, gives him bread and jelly between meals at frequent intervals, "so that he will not starve to death," with the result that he is never hungry. The candy habit also plays an important part, fathers with "lollypops" being often at the bottom of it.

The first essential in treatment is to give the child nothing

whatever between meals. He comes to the table, sits there quietly until the meal is finished, and gets nothing until the next meal, whether he has eaten or not. Physical and mental rest is of the utmost importance, and in severe cases it may be necessary to take the child from school for a few weeks so that he can get the necessary rest. He should lie down quietly for an hour after his dinner, and be in the house and quiet at least a half-hour before supper. If he has been going to bed at all hours of the night, as these children frequently do, he should be put to bed earlier. If he has been in the habit of playing with children a good deal older and stronger than himself, he should be separated from them for a while, at any rate, and put with children nearer his own age, if possible. A change of scene is often very beneficial to these run-down, poorly eating children, and it may make little difference where they go, as long as the surroundings are different.

Tonics are usually of some value, and the one which has given me best results is the following:

℞. Tincture of nux vomica........... ʒij;
Glycerinated elixir of gentian....ad. ℥vj.—M.
S.—One teaspoonful in water before each meal (for a child five years old).

With intelligent, tractable children suggestion is sometimes very valuable. At the first visit to the doctor's office a calendar with the days of the month on it is given, together with a number of little gold stars and an equal number of black ones. The child is told that her mother and the doctor want her to eat better, and that the calendar and the stars are to serve as a reminder to her. The calendar is hung in the dining room, and if she has eaten satisfactorily for a day, a gold star is stuck on the calendar. If she has not, a black star is used. She returns to the doctor's office in ten days bringing the calendar with her, and if she can show seven gold stars, she gets a prize, such as a game, book, or doll. The value and desirability of the prize and the disgrace of black stars is impressed upon her most emphatically at the first visit. With certain children this works wonders, as it arouses their interest and gives them something to work for.

CHAPTER XVII

RICKETS

RICKETS is a very common constitutional disease of somewhat obscure and complicated etiology, the chief manifestation of which is a diminished calcium deposition in the growing bone.

Occurrence.—Rickets occurs most commonly between the ages of six and eighteen months, although it is not infrequently seen earlier. The earliest well-marked case that I have myself seen was in a breast-fed baby of three months. It is probable that the cases of so-called "fetal rickets" which have been reported have been, in reality, not rickets, but osteogenesis imperfecta, or chondrodystrophy, and it is questionable if an undoubted case of true congenital rickets has ever been reported. Late rickets, that is, rickets coming on after the age of three or four years, may occur, but is extremely rare. The rachitic deformities that one so often sees in children over two or three years of age do not represent an active rachitic process; the rickets has healed, and the deformities are the remains of it.

It is especially likely to occur in premature babies. Of 70 prematures followed by Huenekens,[1] 58 developed definite rickets. It is not going too far to say that almost every premature develops rickets to a greater or lesser degree; this is borne out by the clinical experience of everyone who is seeing many infants.

It is also very likely to develop in twins.

Rickets is an extremely common condition, especially among the hospital class in the large cities of the temperate zone. Morse,[2] of Boston, in 400 consecutive dispensary babies under two years of age found definite evidence of rickets in 80 per cent.

[1] Journal-Lancet, December 15, 1917.

[2] Jour. Amer. Med. Assoc., vol. 34, March 24, 1900.

This figure corresponds closely with those of observers in other countries. All observers are likewise agreed that it is much more common in the congested districts of cities than anywhere else, and that the poorer classes are the ones that suffer most from it. Mild cases are, however, not uncommon even among babies of the wealthy classes, who have been apparently properly fed and cared for. In the upper classes it is not ordinarily severe, however, and it is probably not possible for any but the very mildest rickets to develop in a baby who was born at full term, and whose feeding and general hygienic care have been satisfactory.

It is a disease of the Temperate Zone, and it is not at all frequent in very hot or very cold countries.

In 1918 Hess,[1] of New York, who has for long been a diligent student of rickets, published letters from several physicians in the tropics, portions of which are quoted.

Dr. J. E. Ker, Jamaica, British West Indies:

"Rickets as we know it in infants in large towns practically does not exist here in Jamaica. Beaded ribs and square heads are of the very rarest occurrence."

Dr. R. Scheult, Colonial Hospital, Trinidad, Port of Spain:

"During my twenty-four years of hospital practice in this colony I have not met a single case of rickets, although hundreds of children are treated in our children's ward each year."

In the large cities of America it is more common in negro and Italian children than in any other groups, and it is rare to see a negro or an Italian child without well-marked evidence of it. Furthermore, the extreme cases of rickets almost always are seen in negroes or Italians. It is not at all common, however, in these races when living in their natural habitat.

Dr. W. B. Pierce of Panama writes[2]: "I have yet to see my first case of rickets in the West Indian negro child. My colleagues who have been here much longer tell me that West Indian children never have rickets."

[1] Jour. Amer. Med. Assoc., vol. 70, March 30, 1918.

[2] Quoted by Hess, loc. cit.

In the United States it is not nearly so common among the rural negroes in the South as it is in the city negroes in the North.

Bottle-fed babies are much more likely to develop rickets than those fed on the breast, although breast-fed infants are not immune, especially those who are nursed too long, without supplementary diet. The seasonal incidence of the disease is rather striking; all statistics show that it is much more common in the winter and spring months than at any other time.

Pathology.—Although rickets is a constitutional disease, in the sense that it affects several tissues of the body, the most important and most characteristic pathologic changes occur in the bones.

In order to understand the changes which take place in rachitic bone it is necessary to understand the essentials of normal bone growth.

A long bone consists essentially of two parts—the epiphysis and diaphysis, or shaft. The epiphysis is formed, in the young, of cartilage. The cartilage cells of the epiphysis, which are in juxtaposition to the end of the diaphysis, are constantly being converted into bone, while the epiphysis itself grows by the formation of new cartilage cells.[1] The zone of tissue which is formed between the true bone of the shaft and the cartilage of the epiphysis is known as "osteoid" tissue, and is converted into true bone in the healthy infant by the extensive deposition of calcium salts. This is called the "zone of ossification," and forms normally a rather sharply defined band at the junction of the shaft and epiphysis. By the continual presence of a zone of ossification and the continual conversion of the cartilage of the epiphysis into true bone the shaft grows in length.

In rickets the specific bone changes are most marked at the junction of the epiphysis and diaphysis, *i. e.*, the "epiphyseal line."

There is a great increase in the zone of proliferating osteoid tissue, *and a failure of calcium deposition in this tissue*, with a

[1] E. H. Nichols, in Keen's Surgery, vol. 1.

consequent absence of the zone of calcification. There is an ingrowth of a dense network of fine blood-vessels into the zone of osteoid tissue, giving rise to an enlarged, hyperemic, and soft epiphysis. The periosteum about the shaft of the bone is also changed, being considerably thickened, and depositing a large amount of new tissue on the cortex. This new tissue is, however, not true bone, and consists partly of cartilage and partly of osteoid tissue, in which no deposition of calcium takes place.

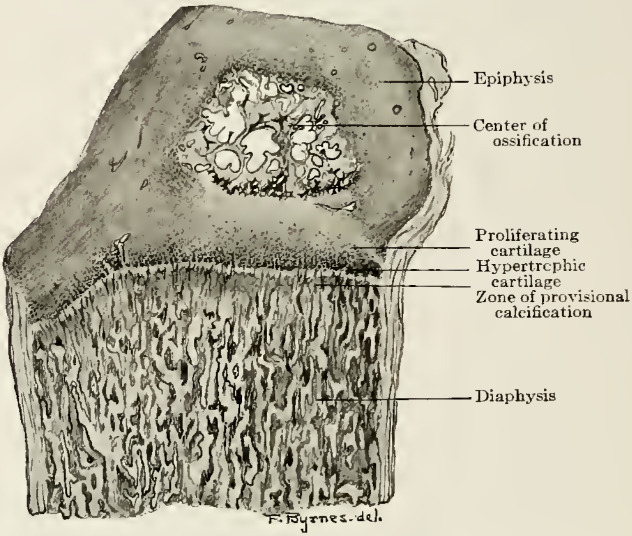

Fig. 8.—A vertical section through the epiphysis and shaft of long bone of child at birth. Low power. (E. H. Nichols, in Keen's Surgery.)

Such a process gives rise to a soft bone, which is easily deformed or fractured if it is subjected to any stress or strain.

Normal bone contains about 60 per cent. of inorganic material, chiefly salts of calcium and phosphorus. A rachitic bone has a greatly increased water and diminished salt content, so that it may contain only 20 per cent. of inorganic material, instead of the normal 60 per cent. During the active stage of rickets there is a greatly decreased calcium retention by the body, in several cases an actual negative balance, that is, more

calcium is given off in the stools and urine than is taken in with the food. During the stage of healing the calcium balance is positive, and more is likely to be retained than would be the case under normal conditions.

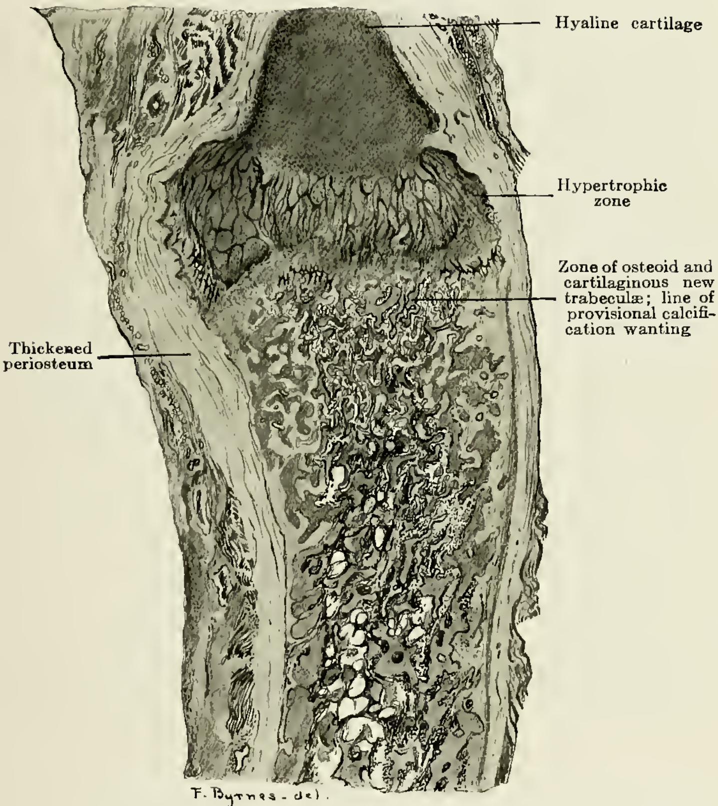

Fig. 9.—Longitudinal section through rib at junction of rib with cartilage from a case of marked rickets. Low power. (E. H. Nichols, in Keen's Surgery.)

One would expect that in such a condition the blood might show a diminution of calcium. This has been studied by Howland and Marriott,[1] who found, however, in 11 well-marked

[1] Prac. Amer. Pediatric Soc., 1916.

cases of rickets that the calcium content of the blood was normal or nearly normal.

Etiology.—*Not enough calcium is deposited in the growing bone.*

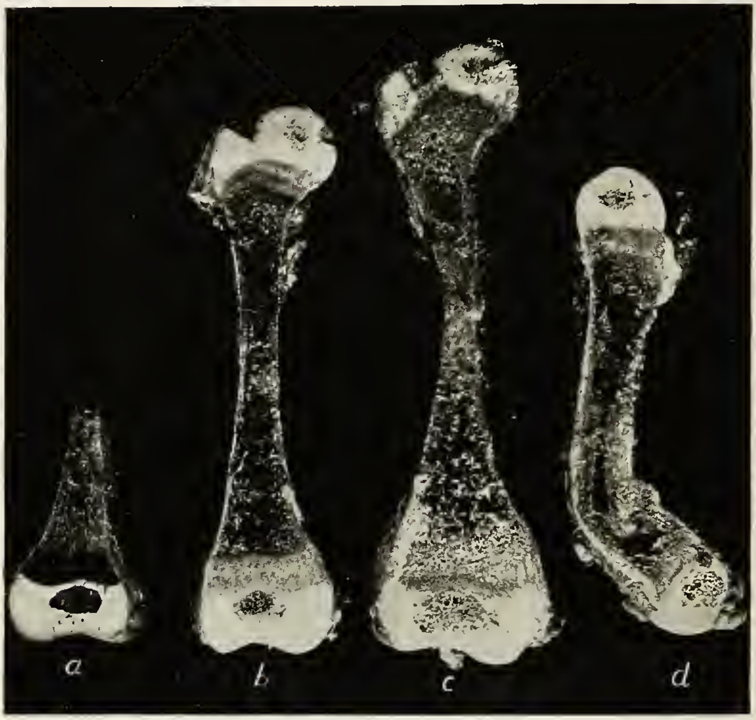

Fig. 10.—Rickets: *a*, Normal bone with clear line of ossification; *b* and *c* show broad bands of osteoid tissue instead of this line; their diaphyses are firm, delicate, and straight; *d*, form of rickets in which the diaphysis is weakened, covered with periosteal new bone, and fractured. (MacCallum.)

This is the central fact of rickets, and is perfectly clear. The hard thing to explain is *why* not enough calcium is deposited, what conditions bring about the faulty calcium metabolism, and despite much investigation the etiology of rickets still remains obscure. It is not exaggeration to say that almost every pediatrist of experience has offered an explanation of rickets,

and the literature is, therefore, flooded with many contradictory and widely varying theories, some of which are very far fetched and have little basis in fact.

There are two main ways to get at the problem.

1. The method of statistical inquiry and clinical observation applied to actual cases of rickets in infants. The type of child in which rickets develops, the seasonal and racial occurrence, the clinical results of various forms of therapy, and so on, represent substantial facts from which valuable conclusions may be drawn.

2. The experimental method, applied largely to animals, the production of artificial rickets by various agencies, and a study of the chemistry of the condition so produced.

Clinical Observations.—All clinical observers are agreed that three main facts stand out in any consideration of the etiology of rickets:

(*a*) That babies who are poorly fed are most likely to have it.

(*b*) That poor hygiene, poor air, poor living quarters, and all that goes with poverty has a great deal to do with it.

(*c*) That full-time babies who are fed correctly and who are brought up under the best of hygienic conditions are very unlikely to have rickets, and if they do have it, it is only in the mildest form.

Clinically, one sees rickets especially in babies who have been fed on diets containing a large amount of carbohydrate, with inadequate amounts of fat and protein. It is common in babies who have been fed on condensed milk, or on proprietary foods which contain large amounts of sugar and starch, and but little of the other food elements. Most observers are agreed that a fat-poor and carbohydrate-high diet predisposes to rickets.

It also often occurs in babies who have suffered from chronic fat indigestion of the type with soapy stools, where the fat and protein intake is high and the carbohydrate intake low.

It is also fairly common in breast-fed babies who have been kept on the breast too long; and have presumably suffered a

salt starvation. There is a possibility, however, that some of these cases may not be true rickets at all, but osteoporosis.

It has been noticed clinically for years that babies who do not go out of doors much and who get but little sunshine are very likely to develop rickets. This is so striking that some observers have thought that lack of fresh air was the entire cause of the disease.

Chemical and Experimental.—The hypotheses that have been offered to explain the essential pathologic fact of rickets, *i. e.*, that not enough calcium is deposited in the growing bone, are three in number:

1. Lack of calcium in the diet. This theory has little to support it, as the blood calcium, according to the few investigations that have been carried out, is practically normal. Furthermore, in animals it is not possible to produce true rickets by calcium starvation. It is true that a condition called "osteoporosis" is produced which somewhat resembles rickets, but is not identical with it. In this condition the bones are soft, and their calcium content is diminished, but the microscopic changes are not those of true rickets. As soon as adequate amounts of calcium are offered in the diet the bone quickly absorbs it, while in true rickets the giving of calcium does not bring about increased calcium deposition.

Furthermore, in most cow's milk mixtures which are fed to babies who develop rickets there is a large excess of calcium over the amount needed.

2. That adequate amounts of calcium may be given in the food, but that it is not absorbed. The argument against this theory is that the blood calcium is normal, and that if the absorption of calcium was insufficient, osteoporosis, and not true rickets, would result (Howland).

3. That calcium is absorbed in sufficient amounts, but that for some at present unknown reason the growing bone is unable to absorb it. This theory is reached by a process of exclusion, and by the fact that the blood calcium is present in normal amounts. It is the theory held at present by most students of the disease.

It is quite another question upon what factors the inability of the growing bone to absorb calcium depends, and is at present unsolved.

It is possible to produce rickets in rats and in puppies in a number of different ways, and at the present time much research work is being done on this phase of the problem, especially by investigations in this country and in England. Attention has been centered especially on a lack of the fat-soluble vitamin and phosphate in the diet.

Mellanby[1] in 1919, as a result of extensive investigation on puppies, reached the conclusion that lack of the fat-soluble vitamin in the diet had, at any rate, a great deal to do with the development of rickets, and brought forward a good many apparently valid arguments to sustain his conclusions. He found that cod-liver oil, butter, and suet, all of which contain considerable amounts of "fat-soluble A," had a well-marked protective action against the development of the disease in pups. Vegetable juices were also found to have some inhibitory effect.

He also showed that an abundance of calcium would not protect when the diet was deficient in the "antirachitic factor." He believed that if milk is to contain the antirachitic factor, the diet of the individual from whom the milk comes must contain an adequate amount of it, such as grass for cows, or green vegetables and butter fat for nursing women. He believed that lack of these substances in the diet of nursing mothers might explain why rickets occurs sometimes in breast-fed babies and why it is more common in bottle-fed babies in the winter months, when the cow's diet is likely to contain little fresh, vitamin-containing food.

"An adequate diet is itself a unit, and its soundness, to a large extent, consists in the mutual assistance and interplay in the metabolic changes the elements experience in the body. The absence of or deficiency in one element means the ineffectiveness of another. It is possible to imagine an abundance

[1] Lancet, March 15, 1919.

of accessory food factors in the diet which may, however, be ineffective because of some wrong balance in the energy-bearing materials" (Mellanby).

This would indicate that the writer believed the fat-soluble vitamin to have a regulatory effect upon calcium metabolism.

After Mellanby's work in 1919, the Vitamin Committee of the British Research Council decided that rickets was definitely a deficiency disease, probably due to lack of "fat-soluble A" in the diet, and stated this in their extensive report.[1] This was apparently a somewhat premature conclusion, as Mellanby's views have by no means been accepted by other students of rickets, notably Paton and his collaborators in England, and McCollum, Hess, Park, Howland, and their associates in this country. Paton, Findlay, and Watson[2] found that pups kept in the country under the best hygienic conditions and fed on a diet containing practically no "fat-soluble A," but allowed plenty of exercise and fresh air, developed no rickets whatever, but that if pups from the same litter were kept in the laboratory under ordinary laboratory conditions with lack of fresh air, sunshine, and exercise, and fed on a diet containing an abundance of "fat-soluble A" in the form of butter fat, they almost uniformly developed rickets. They conclude that under ordinary laboratory conditions a liberal allowance of "fat-soluble A" neither prevents the disease nor cures it after it has developed, and they do not agree that it is essentially a deficiency disease.

McCollum[3] and his collaborators found that rickets might develop in experimental animals on diets in which the faults lay in somewhat different factors, and that a low content of "fat-soluble A," a low calcium, poor quality of protein, and unsatisfactory salt combinations might all contribute to the etiology of the disease.

"Any suggestions regarding the absence of a specific antirachitic substance or deficiency of "fat-soluble A" or calcium

[1] Med. Research Commission, spec. reprint series No. 38, London, 1919.

[2] Brit. Med. Jour., April 23, 1921.

[3] Jour. Biochem., vol. 41, 1920.

as the primary agent in the production of rickets would be ill considered, and might be far from the truth. A specific lack of "fat-soluble A" cannot be regarded as the sole and only possible cause of the disease. At present it is only possible to say that the etiologic factor is to be found in an improper dietetic régime" (McCollum et al.).

Hess and Unger,[1] in a study of the effect of diets poor and rich in "fat-soluble A" upon the development of rickets in infants, showed that the lack of this factor did not cause an increased frequency of occurrence, and in several papers have stated that they do not believe it is the cause of rickets.

"Our experience leads us to believe that except under exceptional circumstances, as in time of war, the danger to the infant and to the child from a deficiency of the fat-soluble factor is one not to cause great apprehension. There is a growing danger of attributing every unexplained growth impulse to the new, attractive, but ill-defined vitamins—of their sharing with the secretions of the endocrin glands the fate of becoming the dumping ground for every unidentified factor" (Hess and Unger).

There is recent evidence to show that lack of phosphorus in the diet, or improper assimilation of it, may have a good deal to do with rickets.

Park[2] and his associates found that in rats a diet low in phosphorus and "fat-soluble A" produced a condition closely resembling rickets. When the deficiency in phosphorus was made up, the deficiency in "fat-soluble A" still existing, no rickets developed. They believe that:

1. The phosphate ion may be a determining influence for or against the development of rickets.

2. The level of the blood phosphorus is, in all probability, determined in part by the amount of the "fat-soluble A" available for the needs of the organism.

Sherman and Pappenheimer[3] were able, by the use of a

[1] Jour. Amer. Med. Assoc., January 24, 1920, vol. 74.

[2] Bull. Johns Hopkins Hospital, May, 1921.

[3] Proc. Soc. Exper. Biol. of Med., 18, 193, March, 1921.

simple diet lacking phosphorus, to produce rickets in rats in every case. Complete protection was afforded by the addition of 0.40 per cent. potassium phosphate to the diet.

Another point in favor of lack of phosphorus being concerned with the etiology of rickets is furnished by the work of Howland and Kramer,[1] who found that after the administration of cod-liver oil to cases of rickets the blood phosphorus was greatly increased, and that in active cases of rickets the blood phosphorus was always decidedly lower than normal.

It must be concluded from the experimental and clinical investigations upon the etiology of rickets that it is a metabolic disease concerned in some way with faulty calcium metabolism, and caused by improper feeding and hygienic conditions. It is fair to say that calcium, phosphorus, and the fat-soluble vitamin probably have certain interrelationships, the normality of which must be maintained in the metabolism if rickets is not to develop. Further than this we cannot go at present without unwarranted theorizing.

As a summary it may be well to set down in numeric order ten established facts which we do know concerning the etiology in human infants and which will some day fit together into a well-connected whole when the exact cause is discovered.

1. The essential pathologic perversion is a lack of calcium deposition in the growing bone.

2. It is not caused by a lack of calcium in the food.

3. The blood calcium is essentially normal in quantity, the blood phosphorus diminished.

4. It occurs especially in infants who have been fed on diets high in carbohydrate and poor in fat, protein, and salts.

5. It also occurs frequently in infants fed on diets high in fat, especially when fat indigestion is present, of the type with constipated light colored stools, containing a large amount of calcium soap.

6. It occurs in about three-quarters of all premature babies, provided they are a month or more premature. It also occurs frequently in twins.

[1] Proc. Amer. Ped. Soc., 1920.

7. Poor hygienic surroundings, lack of sunlight, and fresh air undoubtedly have something to do with its causation.

8. It occurs much more frequently in the winter and spring than at any other time.

9. It occurs more frequently in negroes (and Italians) than in any other races when they are living in the large cities of this country. When they are living in their native habitat it is not common. It has been found that negroes with rachitic children in New York eat very little fresh fruit, fresh vegetables, and milk products, and rickets flourishes. In their native habitat they eat large amounts of green vegetables and fruits, and have practically no rickets.[1]

10. Cod-liver oil possesses marked antirachitic powers, both as a prophylactic and as a cure. It is rich in "fat-soluble A."

Symptoms.—The onset is gradual, and the early symptoms may extend over a considerable period of time before well-marked rachitic lesions of the bone are seen. Sweating about the head and restlessness at night are always given as two of the most important symptoms of early rickets, and while it is true that rachitic babies do sweat about the head, it is also true that many normal babies do likewise, and it is not uncommon to see a baby's pillow drenched with sweat when he is perfectly healthy and has not then or at any other time a sign of rickets. Adults vary greatly in their tendency to perspiration. So do infants, and, therefore, sweating about the head by itself cannot be taken as a very important diagnositc sign of rickets. Restlessness at night is likewise often due to other causes, but when these two symptoms occur together, especially if there is also a loss of appetite, and a flabby condition of the flesh, a condition of early rickets is probable. Poor color, a flabby condition of the flesh, and loss of appetite, especially the two former, are signs from which practically no rachitic infant is free, and are often the earliest signs noted. In the periodic inspection of one's feeding cases early rickets must always be watched for, and the pasty color with rather bluish discoloration under the

[1] Hess and Unger, Jour. Amer. Med. Assoc., vol. 70, March, 1918.

eyes and over the bridge of the nose, together with poor tissue turgor, often indicates beginning rickets, and the desirability of prophylactic cod-liver oil therapy.

Not a few apparently well-cared-for infants in private practice will show these four early signs, combined perhaps with a

Fig. 11.—Rickets, characteristic "square head" and enlarged wrist epiphyses.

slight rosary, delayed dentition, and a fontanel somewhat larger than normal. In most cases with proper treatment the condition goes no further.

Rachitic infants vary greatly as regards their apparent

general nutritional condition; many are fat and of good weight, others are emaciated and obviously in poor condition. All have poor tissue turgor, whether fat or thin.

In well-developed rickets the following are some of the more important changes seen. They may exist all together in severe cases or more frequently only three or four rachitic manifestations will be well marked.

Fig. 12.—Roentgenogram of skull, showing frontal thickening.

The *head* is large in relation to the chest, and often shows the characteristic frontal bosses, which consist of a thickening of the bone on both sides of the head in the frontal region. This characteristic shape of the head may persist for years.

The bone of the skull is often considerably thickened, which is well shown in Fig. 12.

In the acute stages of the disease, especially in young babies, the bones of the skull are often very soft, and the head may be flattened on the back or on the side upon which the baby is accustomed to rest. In some cases the back of the head is very flat and the forehead protuberant, giving rise to a brachycephalic type of skull.

Craniotabes is not uncommon. This consists of areas of softening in the skull bones, most common in the parietal region. They vary from the size of a dime to that of a quarter. When pressed by finger these areas may give a crackling sensation like heavy parchment, or may feel soft and doughy. Craniotabes is most commonly seen at the third or fourth month, when perhaps there are few other signs of rickets, but it may always be considered (excluding syphilis) as a sign of severe rickets. It is likely to disappear at the eighth or ninth month, when the other signs, such as enlarged epiphyses and rosary, begin to be more prominent. The sutures of the skull may be widely open, and the fontanel almost always is larger than it should be for the age of the child, and closes late. The anterior fontanel should close normally at the eighteenth month, and in many well-developed infants will be closed considerably before this. In rickets it may be widely open as late as two years or after. According to Still, if it is greater than 1 inch in each diameter at one year of age it is abnormal, and indicates a probable rachitic process. This is probably true even if there are few other signs of rickets, and the rate at which the fontanel closes is one very good index of a baby's general development.

The Teeth and Jaws.—The teeth are late in erupting, but individual babies vary so much in the time at which the first teeth appear that delayed dentition alone cannot be taken as an indication of rickets. I saw not long ago a perfectly normal child of thirteen months who did not have a tooth in her head, and yet had no signs whatever of rickets. She did not cut her first tooth until fourteen months. This is, of course, abnormal

dentition, and yet the child herself was perfectly healthy. Many babies will begin to cut teeth at six months, but dentition need not be considered abnormal unless the appearance of the first teeth is delayed until the eighth month. According to Morse[1] a normal infant should have 1 tooth at eight months, 2 at nine months, 6 at twelve months, 12 at eighteen months, and 16 at two years. These figures are all somewhat later than the average. Defective calcification of the enamel is marked, but is most likely to be seen in the permanent dentition, as calcification of the deciduous teeth begins in the fifth or sixth month of intra-uterine life, and would naturally not be affected so much as that of the permanent teeth, which should be taking place while the rachitic process is going on.

In the typical rachitic form of hypoplasia met with in the permanent teeth the ones most affected are the central and lateral incisors, the tips of the canines, and the crowns of the first molars (Dick).[2]

The deciduous teeth are lost early, with a resulting malocclusion in the second dentition, and it is probable that rickets is one of the most potent causes of this malformation. The upper jaw is narrowed or V shaped in form; the palatal arch is vaulted and narrow, and the teeth, therefore, crowded.

The Long Bones.—It is in the long bones of the body that the most striking manifestations of rickets appear. The *clavicles* very frequently show an angular bending outward, often due to green-stick fractures, or again the bone may be much shortened on account of old fractures, and calluses may be felt.

The *ribs*, in common with the rest of the bones, are soft, and this may give rise to marked deformity of the chest. The rachitic chest is usually narrow at the top, and flares out broadly at the base. There is often a depression at the junction of each rib and costal cartilage especially marked from the fourth to the eighth ribs, giving rise to the so-called "Harrison's groove." At the junction of the rib and cartilage there is an

[1] Jour. Amer. Med. Assoc., 1900, vol. 34, March, 1824.
[2] Brit. Jour. Dis. Chil., vol. 13, November, 1916.

overgrowth of osteoid tissue (see Pathology), forming small bead-like excrescences which can be seen and felt on the outside of the chest wall. This is the so-called "rosary," and is

Fig. 13.—Narrow flaring chest, also characteristic pot-belly and extreme pronation of the feet.

Fig. 14.—The rosary.

one of the most common signs of rickets, and it is probable that no rachitic child is without one. It has been said that a "rosary" is a pathognomonic sign of rickets. Beading of the ribs or "rosary," according to Hess and Unger,[1] also may occur

[1] Jour. Amer. Med. Assoc., vol. xix, May 20, 1920.

in scurvy when uncomplicated by rickets, so it is probably not correct to regard it as a pathognomonic sign. A good many apparently normal babies will show slight beading of the ribs, and it is often difficult to know what should be called a rosary and what not. There is no very definite standard to go by,

Figs. 15, 16.—Contrast between knock-knee and bow-legs.

but personally I should call any beading that was plainly visible to the eye a rachitic rosary, and would pass any beading not visible to the eye as normal unless each bead were about as large as one's little finger-nail. The state of nutrition of the child has, of course, a good deal to do with the visibility of the beading.

The *extremities* show striking changes. There may be ex-

treme bowing of the bones of the arm and the leg, with multiple fractures. The most common deformity is lateral bowing of the tibiæ; the femur and bones of the arm are not so likely to be affected. The deformity of the legs may vary all the way from slight bowing to the most extreme changes (Figs. 15, 16).

Knock-knee may also occur, and may sometimes be so severe as to seriously interfere with locomotion. The legs

Fig. 17.—Various degrees of deformity due to knock-knees. Note marked flat-foot in all cases.

of many rachitic babies before they begin to walk may show no bowing or knock-knee, but may be very small and tapering, so weak and flabby that walking is long delayed, and the physician who is not familiar with rickets may mistake the condition for a paralysis of some sort. There is a great laxity of the ligaments, which is likely to cause pronation of the feet, in many cases so extreme that the baby cannot walk until it is corrected.

The epiphyses at the knees and ankles are enlarged, and may be somewhat tender in the florid stage, but the most striking epiphyseal changes take place at the wrist. These epiphyses may be very much enlarged, and such enlargement is always an indication of a considerable degree of rickets. In the milder cases they may be enlarged so slightly as to be scarcely noticeable, but the Roentgen ray will show the characteristic rachitic changes.

The Spine.—Kyphosis is common. The curve is usually a rather long, gradual one, occurring most commonly in the lower thoracic and lumbar segments. The curve seen in tuberculosis of the spine is shorter and more angular, and it is not ordinarily difficult to differentiate the two conditions. The rachitic kyphosis is flexible, and when the baby is put upon its abdomen and the spine flexed by raising the legs the curve has a tendency to straighten out and does not show the degree of inflexibility and spasm that would be likely with a tubercular spine. Lateral curvature is likewise not uncommon.

The Roentgen-ray Appearance of the Bones.—The Roentgen ray is often of value in the diagnosis of rickets, and is always valuable in determining the stage in which the rachitic process is, whether it is progressive, in the so-called "florid" stage, or whether it is healing. According to Lovett[1] by Roentgen-ray examination three fairly distinct changes may be recognized in the course of the rachitic process:

1. Swelling and rarefaction.
2. Deformity and organization.
3. Healing and reparation.

First Stage.—In the milder types the ends of the diaphysis become frayed instead of clear cut, and the epiphysis casts little or no shadow. The center of ossification is small or absent. In the severe type the epiphyseal changes are similar, but more marked. In the shaft there is general bone atrophy and often multiple fractures.

Second Stage.—The shadow of the epiphysis is more marked,

[1] Jour. Amer. Med. Assoc., December 11, 1915.

but ragged and irregular. The ends of the diaphysis begin to broaden. At the end of the diaphysis next to the epiphyseal line there often appears in the late second or early third stage a clean transverse white line, showing an increased deposit of lime in the shaft. This is apparently not to be distinguished from the white line of scurvy.

Third Stage.—The epiphysis begins to assume its normal contour and shadow density. This represents the period of convalescence, and from this point on the deposition of bone continues.

Fig. 18.—Schematic representation of various changes in the bone during the different stages. (Courtesy of Dr. R. W. Lovett.)

As a summary of the general changes as seen in rickets Lovett says, "The epiphyses show scanty and irregular osseous deposits and never have a clear-cut outline during the acute process. The end of the shaft is streaked and presents an irregular line at the joint end and above it a curious transverse zone of different structure from the rest of the bone. The interior of the shaft becomes chambered and irregular, and the whole shaft casts less shadow than normal. The ends of the shaft broaden at the junction with the epiphysis and put out

ledges on the side where strain is to be met. A compensatory cortical thickening occurs on the concave side of curved long bones."

Systemic Changes.—In rachitic children with extreme deformity of the chest respiration may be much interfered with, even to such an extent that life may be threatened, as Park and

Fig. 19.—Figures 19 to 22 inclusive are all from cases of rickets in the florid stage. Note especially the frayed-out appearance of the ends of the diaphyses and the indistinctness of the epiphyses.

Howland[1] have recently pointed out. There may be a progressive reduction in the size of the thorax, and loss of power to expand, followed by atelectasis of portions of the lungs, consequent impediment to the pulmonary circulation, and hypertrophy of the right side of the heart. With very severe deformity the power of the respiratory apparatus may be barely

[1] Bull. Johns Hopkins Hosp., 32, 101, April, 1921.

sufficient for the needs of the body, and if any pulmonary infection is added it fails and death results.

A low-grade, patchy type of bronchopneumonia is responsible for many deaths in rachitic infants, and this is indeed the chief danger to life that rickets offers.

Fig. 20.—Knee: Florid stage.

Most rachitic children are anemic, occasionally to a severe degree, the anemia being of the ordinary "secondary" type with low hemoglobin and moderate diminution in the numbers of the red cells. This anemia is often associated with enlargement of the spleen, and probably a good many cases of "Banti's disease"

and "pseudoleukemia" that have been reported in infants have had rickets as their basis. The spleen is frequently slightly enlarged in moderately severe cases without much anemia, and should always be carefully felt for if rickets is suspected, as it is a diagnostic point of some importance. It is often difficult to

Fig. 21.—Knee: Florid stage.

feel a slightly enlarged spleen in a baby. The mistake that many people make is to press in too deeply, and to feel with too large an area of the fingers instead of with the tips alone.

There is likely to be a slight enlargement of the lymph-nodes.

This is, however, not especially characteristic of rickets, and may occur in any poorly nourished infant.

The liver is enlarged in some cases, particularly if the diet has been very high in carbohydrate.

The nervous system in rickets shows an increased irritability. It may take the form of spasmophilia, which is so often associated with rickets, or it may manifest itself simply by restlessness on the part of the child, especially at night, and by a

Fig. 22.—Ankle: Florid stage.

tendency to jump at noises or any unexpected sudden motion on the part of the nurse or the mother. The disposition is likely to be peevish and fretful, and in a hospital ward a child with severe rickets is usually the "bad boy" of the ward.

The tone of the muscles is poor, and in some cases the leg muscles may be so weak as to suggest paralysis. The abdominal muscles are also thin and weak, giving rise to the "pot belly"

and soft relaxed abdominal walls which are so characteristic of this disease.

The hair is sparse, and owing to the nervousness of the child and his tendency to roll his head about, it may wear off in spots, giving rise to a patchy, moth-eaten appearance.

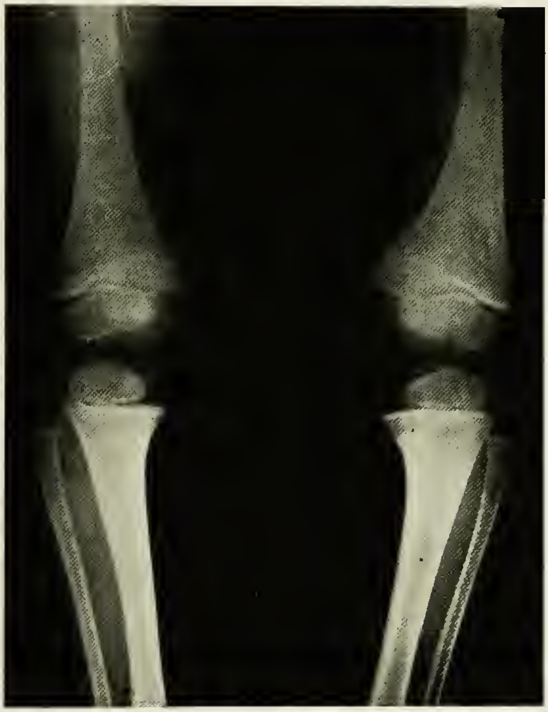

Fig. 23.—Stage of healing. Note especially the clearer outline of the epiphyses, also the broadening of the ends of the diaphyses. The white line is also visible, but not so marked as it is in some cases.

Diagnosis.—A well-marked case of rickets can scarcely be confused with anything else.

It is sometimes difficult to decide, however, in the early stages how much evidence is necessary before it is allowable to make the diagnosis. Head sweating, restlessness at night, enlarged fontanel, slow dentition, poor tissue turgor, and slight

rosary constitute enough evidence upon which to base a diagnosis of early rickets. Later on the enlarged epiphyses, shape of the head and chest, bowing of the legs, etc., make an unmistakable picture.

Fig. 24.—Stage of healing. Note especially the thickness of the tibia and the white line at the lower diaphyseal end.

Chondrodystrophy fœtalis is a condition which has sometimes been mistaken for rickets. This begins in fetal life and consists of a disturbance of ossification resulting in a premature ossification of the cartilage, with a consequent *short* bone. The arms and legs are very short in relation to the trunk, there

is no rosary, and the epiphyses are not enlarged. The x-ray shows a normal appearing epiphysis, "which maintains its clearness and regularity of outline throughout the affection" (Lovett). The diaphyseal ends of the long bones also are sharp and clean cut in outline, and never show the frayed appearance so characteristic of rickets.

In *fragilitas ossium* there are multiple fractures, but this is its only real resemblance to rickets. The long bones are very slender, and show an extreme fragility, so that they fracture on the very slightest provocation. The epiphyses show none of the characteristic changes seen in rickets.

Osteogenesis imperfecta is usually seen in stillborn babies. The bones are very thin and extremely soft, more so than in rickets, and bend easily in all directions. The bones of the skull are especially very soft and thin, so that the cranium may be almost entirely membranous. The condition is incompatible with life, and infants with it usually die soon after birth.

Scurvy probably bears no etiologic relationship to rickets, but the two often coexist. In rickets there may be some pain in the legs, especially about the knee, but it is never as severe as the pain in scurvy, and most of the cases which have been called "acute rickets" are, in reality, probably scurvy. In scurvy the trouble is along the shaft of the bone, in rickets mostly in the epiphysis. In scurvy the x-ray shows the clear outline of the epiphysis, in rickets it does not. The "white line" is present in both. "On the appearance of the epiphysis alone it is possible to differentiate the two diseases" (Lovett).

Prophylaxis.—The prophylaxis of rickets is important, and it is theoretically possible by proper prophylaxis to do away with the disease. Sunshine, fresh air, and proper feeding are the cornerstones of prophylaxis, and it is probably true that few babies will develop rickets if they are properly fed and get a sufficient amount of outdoor air. Under proper feeding comes weaning at the right time, which should be done in most cases not later than the eighth or ninth month; babies fed at the breast longer than this will certainly in many instances develop

rickets. Whether or not green vegetables are of any value as a prophylactic is an undecided question. The fact remains, however, that babies fed upon suitable milk modifications—cereals, soups, and beef juice—up to the fourteenth or fifteenth month, and cared for adequately as to their general hygiene, do not develop it, so it would seem that green vegetables are not necessary as a prophylactic, provided the diet is suitable in other respects. Cod-liver oil is of unquestioned prophylactic value, and it has its particular field of usefulness in premature babies, who are so likely to develop rickets. It is a good idea with all prematures, at the third or fourth month, to begin feeding cod-liver oil in doses of 10 to 20 drops three times a day, which may be increased at the eighth month to $\frac{1}{2}$ teaspoonful or even a whole teaspoonful at a dose.

Rickets is such a wide-spread disease that it must be borne in mind that any feeding case or apparently normal baby in one's practice *may* develop it. Prophylaxis and a careful examination for early rickets each time the baby is seen are, therefore, important.

Treatment.—The treatment of rickets is satisfactory and good results may be obtained.

Feeding.—If there is any special type of indigestion present, this must be corrected. The most common type likely to be found is a chronic fat indigestion with constipated stools containing a large amount of soap; the stools should, therefore, be examined. If the baby has been on a diet high in carbohydrate and low in protein and fat, the carbohydrate should be reduced and the fat and especially the protein raised to the limit of tolerance. A mixed diet should be begun as early as possible; rachitic babies almost always do better on this sort of diet than on milk alone. Orange juice may be used any time, small amounts of strained oatmeal and meat soups may be begun at the seventh month, while spinach or carrot purée and beef juice may be started at the eighth or ninth month. Egg yolk is also of value, and may be given at the end of the first year. It is best given by hard boiling the egg, separating the yolk from the white,

grating it, and mixing it with the vegetables or cereal. The rachitic child will, therefore, be taking a much more varied diet than would a normal child of the same age. It is hard to explain scientifically, in view of what we know concerning the etiology of rickets, why green vegetables should be of value in the treatment, inasmuch as it is not generally believed that lack of the fat-soluble vitamin, which is contained in considerable amounts in green vegetables (especially spinach) is the cause of the disease. Also, inasmuch as it is not caused by lack of calcium in the diet, the moderate amounts of calcium contained in vegetables would not be especially indicated. The fact remains, however, that green vegetables in the diet do seem to do good in the treatment, whatever the exact explanation may be.

Drugs.—Cod-liver oil and *phosphorus* have for long been used in the treatment of rickets. This combination was first extensively used by Kassowitz about 1880, and had considerable popularity for a while, after which it rather fell into mild disfavor for a period, but in the last few years has had a great revival of popularity. At present practically all students of rickets are agreed that cod-liver oil alone, or combined with phosphorus, is of great value, and it has been shown by several investigators that cod-liver oil when ingested increases the retention of calcium and of phosphorus by the growing bone. It is probably even more efficient when combined with phosphorus than when used alone. Prolonged administration is necessary if the best results are to be obtained, but Howland and Park[1] were able to show by means of the x-ray that there was definite calcium deposition in the "osteoid" tissue as soon as three weeks after beginning treatment with cod-liver oil. The reason why administration of cod-liver oil should increase the deposition of calcium in the growing bone is not known. It is rich in the fat-soluble vitamin, and contains a not inconsiderable quantity of iodin; aside from this there is probably nothing different about it chemically from any other fat. The usual dose of cod-liver oil to begin with for a baby of six months

[1] Arch. Ped., 37, 1920.

or under is about 20 drops three times a day. After the ninth or tenth month a teaspoonful at a dose may be taken. Babies usually take it readily, and it is less likely to upset the stomach or to cause loss of appetite if it is given immediately after the feeding than at any other time. If the stools begin to smell like cod-liver oil this is a sign that it is not being well assimilated, and is an indication for a reduction in the dose.

If it is desired to use phosphorus in conjunction with the cod-liver oil, the best prescription is the following:

℞. Phosphorated oil .... ʒss;
Cod-liver oil .... ℥iv.—M.
Shake well before using.
S.—One teaspoonful three times a day.

Each minim of the official phosphorated oil of the Pharmacopeia contains about $\frac{1}{120}$ grain of phosphorus, therefore each teaspoonful dose of the above prescription would contain about that amount. Phosphorated oil is heavier than cod-liver oil and has a tendency to settle to the bottom of the bottle, therefore it must be shaken vigorously before using, as, if it is not, the last dose in the bottom of the bottle might contain enough phosphorus to poison the child.

Calcium.—There is probably no advantage in giving calcium salts to a baby with rickets, inasmuch as the food contains a great sufficiency, and it is probable that increasing the amount of calcium in the diet has no effect on the retention of calcium.

Tincture of Nux Vomica.—Small doses of tincture of nux vomica may be of value for rachitic children over a year old, particularly if they are constipated. A child of this age would take from 1 to 1½ minims three times a day. It is best given in orange juice.

Iron.—Inasmuch as almost all rachitic children are somewhat anemic, some markedly so, iron is usually indicated, and seems to do good. The best iron preparation for babies is the saccharated oxid, and is prescribed in powder form, a pinch or

two to be given three times a day in orange juice, or mixed with the food.

℞. Saccharated oxid of iron (powdered), ℥ij.
S.—One pinch three times a day.

General Treatment.—Sunshine and fresh air are of the utmost importance. The rachitic baby should be out of doors as much as possible on the sunny side of the house. In summer there is no place like a beach for a rachitic child, and a month or two at the seashore sometimes works wonders. If the child is old enough he may be put on the beach in his pen, and may spend most of the day there. Several competent observers have thought that lack of light had a good deal to do with the development of rickets, and it certainly seems as though this might be true in some cases. On a broad beach of light colored sand the light is intense on sunny days, and it is, therefore, an ideal place to secure any possible therapeutic effect that light may have.[1] Salt-water baths are also of value, and if a rachitic baby is at the seashore they should certainly be used.

The rachitic baby should not be urged to sit up or to walk, but should be left to his own devices in this respect. He should be rather held back than pushed ahead, as if he walks much while the rachitic process is still active, particularly if he is a heavy baby, any bowing of the legs will become much intensified.

Prevention of Deformity.—The treatment of the deformities resulting from rickets is an orthopedic problem, and there should be a close co-operation between the pediatrician and the orthopedist in this respect. It is well not to wait too long before calling in the orthopedist, as by the use of suitable apparatus he can usually prevent severe deformity from taking place. The three deformities that are most amenable to treatment in the florid stage of rickets and which come under the observation of the medical man are bow-legs, pronated feet, and kyphosis. If the bowing of the legs is at all extensive it is well

[1] Since this was written several papers have appeared, showing definitely that exposure to sunlight increases markedly calcium deposition in rachitic bone.

to have proper braces applied, and in conjunction with diet, cod-liver oil, and hygiene, it is often remarkable to see what good results may be obtained in a few months. Bowing of the legs may occur even before the baby starts to walk, and in these cases the bowing is, of course, greatly intensified as soon as walking begins. It is therefore wise to have the braces applied early, even if the baby is not walking. Braces are also often necessary for weak legs without any bowing.

Extreme pronation of the feet is very common and is due to the laxity of the ankle ligaments. This alone may prevent walking, but responds very readily to treatment, and it is remarkable to see sometimes how well a rachitic child of eighteen or twenty months will walk if he has proper shoes and proper ankle braces, when he could perhaps barely stand before their application. The type of shoe for rachitic children just beginning to walk is of importance. It should be a high laced shoe of fairly heavy leather, with a stiff sole, and often needs a steel ankle shank and a modified Thomas heel in order to throw the balance of the foot outward. A word of warning as to moccasins, which are so popular for young babies of a year or two old. They give practically no support to the foot, and should not be used for either normal or rachitic babies. Mild degrees of kyphosis may be treated by having the baby lie on a hard flat surface and by not allowing him to sit up. More severe cases may need to be kept strapped continually to a Bradford frame.

Course and Prognosis.—Rickets tends to heal spontaneously, and after a few months of diminished calcium deposition increased amounts are retained and the bone becomes hard again. It is not common to see active rickets after the age of two years. The course of the disease without treatment may last anywhere from four to fifteen months. With proper treatment it may be considerably shortened. The end-results with good treatment are usually satisfactory, but depend to a very large degree upon how soon the case is seen. It should be possible in any early case to prevent deformity from occurring. It is remarkable to see how few signs of rickets are left in most cases as the child

grows up if excessive deformities were not present. The legs slowly straighten, the epiphyses come back to normal size, the rosary disappears, and the head assumes a normal shape, so that in a great many cases by the time the child is five or six years old one would not know that he had had rickets. The second dentition, however, is likely to be poor, and there is no doubt that a good many of the carious teeth occurring in childhood have an earlier rickets as their basis.

In some cases the deformity of the legs is so great, either extreme bow-legs or knock-knee, that operation has to be resorted to.

The disease is not ordinarily dangerous to life except indirectly. Rachitic children are prone to infection and bear it poorly. Pulmonary infection of any sort is an especially common cause of death.

CHAPTER XVIII

SPASMOPHILIA

Spasmophilia is a not uncommon chronic disorder of metabolism seen usually in infants, and manifested by an increased irritability of the central nervous system, which shows itself by spasm of the larynx (laryngismus stridulus), carpopedal spasm (tetany), or by general convulsions. It is often latent, in which case it is manifested merely by increased electric and mechanical irritability. It is probably dependent upon faulty calcium metabolism.

Occurrence.—The youngest case reported is by Wolff, in an infant of seven weeks.[1] It is, however, rare before the age of three or four months, and occurs most commonly between the fifth and eighteenth months. It may be seen in older children or even in adults after parathyroid extirpation or in certain gastric conditions.

It is not at all uncommon, and according to various observers occurs in from 1 to 2 per cent. of all infants under two years of age. It is not unlikely, however, that it is much more common than this, as many cases are latent, without active manifestations, and pass unrecognized. It is undoubtedly true that a large proportion of the convulsions seen in infancy, and formerly thought to be due to many varied etiologic factors, actually rest upon a spasmophilic basis. Almost all cases are seen in bottle-fed babies, but it can occur in the breast fed. It is almost always associated with rickets, and has been regarded by some observers not as a separate disease, but as a complication or manifestation of this disorder. This, however, is probably not true, as it is sometimes seen in infants who show no

[1] Arch. f. Kinderheilk., August 31, 1920, 68, 1 and 2.

signs of rickets. It occurs most commonly in poorly nourished infants who have had trouble with their feeding, and is especially likely to be seen in those who have been fed on proprietary foods, or on any mixture excessively high in carbohydrate and poor in the other food elements (cf. Rickets).

The seasonal incidence is very striking. It is most common in the winter and spring, and only rarely occurs during the summer months. In a series of 246 cases collected by Wilcox,[1] 74 per cent. occurred during the months of January, February, March, and April. The highest incidence (24 per cent.) was in March.

Of 47 cases reported by McLean[2] from the Out-patient Department of the Babies' Hospital, New York, none occurred during July, August, or September. There is some evidence to show that there may be a familial tendency to spasmophilia, but it is not a truly hereditary disease.

Etiology.—Numerous theories of etiology have been proposed in the last fifteen years which would be tedious to review, and it is best to confine ourselves to the views held at the present time by the majority of authorities.

The Parathyroids.—The parathyroid glands are small bodies which lie in the fatty and connective tissue about the thyroid, and are usually four to six in number. It is possible to produce a condition very similar to or identical with spasmophilia in infants in experimental animals (dogs) by extirpation of these glands, or in human beings (adults) when the parathyroids have been inadvertently removed during the course of a thyroidectomy.

In experimental animals electric irritability of the central nervous system is increased, the blood calcium is lowered, and there may be carpopedal spasm in the same way that there is in naturally occurring spasmophilia. Furthermore, the same methods of treatment apply to the one as to the other. Also, in a good many infants dying during a period of active spasmo-

[1] Amer. Jour. Dis. Chil., vol. 1, 1911.
[2] Arch. Ped., vol. 37, 1920.

philia, old or fresh hemorrhages in the parathyroid glands are found, and this has led some investigators to the belief that abnormality of these bodies is the cause of the disease. However, many autopsies show lesions of the parathyroids, yet the babies during life have had no symptoms of spasmophilia. Furthermore, inasmuch as many spasmophilic infants show no signs whatever of damage to the parathyroids,[1] and as the condition may be produced in other ways quite independently of these bodies, it is the consensus of opinion that parathyroid insufficiency has little to do with spasmophilia as it is ordinarily seen.

Calcium.—All experimental and clinical evidence points to the fact that faulty calcium metabolism is the most important factor in the etiology of spasmophilia. One of the first observations was the oft-quoted one of Quest,[2] who found that the brains of spasmophilic infants contained less calcium than those of normal infants.

A most significant fact is that the blood calcium is consistently low both in natural and artificially produced spasmophilia. Howland and Marriott[3] found that in normal infants and adults the blood calcium was constantly between 10 and 11 milligrams per 100 c.c. serum. In 18 cases of active tetany the average was 5.6 mgm. per 100 c.c. serum, a reduction of from 40 to 50 per cent. in nearly all cases. In convulsions not due to spasmophilia the calcium content of the serum was found to be normal. These results have been confirmed by other observers. It has also been found that during the active period of tetany there is a considerably diminished retention of calcium, and that as the tetany disappears the calcium retention improves.[4,5]

It is possible either in artificially produced or naturally occurring spasmophilia to relieve the active symptoms, and to

[1] According to Howland and Marriott (Quart. Jour. Med., 11, 289, 1918) parathyroid lesions are the exception rather than the rule.

[2] Jahrb. f. Kinderheilk., lxi, 114, 1905.

[3] Loc. cit.

[4] Schwartz and Bass, Amer. Jour. Dis. Chil., vol. 3, 1912.

[5] Brown and Fletcher, Amer. Jour. Dis. Chil., vol. 10, 1915.

bring about a more normal nerve irritability by the administration of calcium salts.

The Relation of Sodium to Spasmophilia.—The sodium ion acts as a nerve irritant, and excess of this ion in the blood can bring about such an increased irritability as to cause spasmophilia.

Howland and Marriott[1] report 3 typical cases of tetany caused by intravenous injections of sodium bicarbonate for acidosis.

Morse,[2] likewise, reports the case of a girl who was given large doses of sodium bicarbonate at one time, and a considerable amount of sodium phosphate another time for the treatment of a long-standing pyelitis. Both times she developed typical and severe tetany. Her renal function was found to be very poor, with an extreme fixation of specific gravity and a very low phthalein test. At autopsy her kidneys were much atrophied and showed typical chronic "interstitial nephritis." The function of the kidney was so poor that the sodium salts given could not be excreted, but were retained in the blood, and increased nerve irritability to such an extent as to cause tetany. A similar case has been reported by Grulee,[3] and he likewise points out the fact that whey, which is rich in sodium salts, when fed to spasmophilic infants may precipitate an attack of tetany or general convulsions, or may make an already existing tetany worse.

The Interrelationship of Sodium and Calcium.—It is probable that faulty calcium metabolism *alone* is not the cause of spasmophilia, and that the significant fact is the ratio in the blood-serum between the calcium, on the one hand, and the sodium on the other. Calcium is a nerve sedative, sodium a nerve irritant, and in order to maintain the correct degree of nerve irritability there must be a definite ratio between the amount of calcium and of sodium in the blood. Increased sodium or

[1] Loc. cit.

[2] N. Y. Med. Jour., No. 25, December 18, 1920.

[3] Amer. Jour. Dis. Chil., vol. 13, 44, 1917.

diminished calcium cause an increased nerve irritability, *i. e.*, spasmophilia. This disturbance of equilibrium is brought about by faulty metabolism in bottle-fed babies suffering from certain digestive disturbances. The exact mechanism of its production is obscure. This theory has been advocated especially by Brown and Fletcher.[1] It is probably not far from the truth, and has considerable experimental and clinical evidence to support it. The fact that the blood calcium is low, that feeding calcium salts either to dogs with experimental tetany or to infants with spasmophilia reduces the nerve irritability, and that sodium salts either by mouth or intravenously greatly increase it, which has been shown by numerous investigators, are all strong arguments. Brown and Fletcher have also shown that in the active stage of spasmophilia there is a great storing up of sodium and potassium in the body, and a loss of calcium and magnesium,[2] and that when the symptoms begin to improve these conditions are reversed. They believe that free diuresis and free action of the bowels are very important in getting rid of sodium and potassium, and record several cases in which there was great improvement coincident with a diarrhea, during which there was probably a sweeping out of these elements from the body.

Symptoms.—Spasmophilia may be latent, with no symptoms except an increased mechanical and electric nerve irritability, or it may be active, when it is manifested by laryngismus stridulus, tetany, or general convulsions. Slight causes of irritation, such as indigestion, teething, or acute respiratory infections, which would probably cause no nervous disturbance in a normal infant, may be enough in a spasmophilic baby to convert the latent condition into the active.

Signs of Increased Nerve Irritability.—The so-called "Chvostek" sign or "facial phenomenon" occurs in most cases, whether latent or active, and is one of the most practical and reliable

[1] Loc. cit.

[2] Howland and Marriott have found that the magnesium content of the blood in spasmophilia is normal, and believe that this element has little to do with it.

diagnostic signs that we have in spasmophilia. It consists of a quick contraction of the small muscles about the mouth, nose, or temporal region, when the facial nerve is lightly tapped, either with the finger or with a small percussion hammer, in the middle of the cheek just under the malar bone. Escherich[1] records this sign in three degrees as follows:

1. A slight twitching at the angle of the mouth or of a small muscle bundle in the nose or forehead.

2. A strong twitch at the corner of the mouth, alæ nasi, or labialis or frontalis muscles.

3. A definite twitch in all the muscles supplied by the facial nerve.

The Peroneal Sign.—This sign is elicited by tapping lightly over the peroneal nerve at the head of the fibula on the outside of the leg. A quick outward jerk of the foot follows.

Trousseau's Sign.—If the upper arm or leg is constricted by compressing the limb with a tourniquet, typical carpopedal spasm may result. In our opinion this is not a very valuable sign, as it is absent in many cases of spasmophilia, and it is not of enough value to subject the baby to the discomfort and possible danger of carpopedal spasm. If it occurs it is, however, pathognomonic. It is not a necessary sign for the diagnosis of spasmophilia, and I have given up even trying for it on account of the reasons given above.

Electric Irritability.—Increased irritability of the nervous system as measured by the response (usually of the peroneal nerve) to stimulation by the galvanic current is the most characteristic, constant, and reliable finding in spasmophilia. This is known as Erb's phenomenon. The determination of the electric reactions is undoubtedly the most accurate method of diagnosing the condition and of following the results of treatment. It is not an especially complicated test to perform by those who are familiar with it, but requires a certain amount of electric apparatus and considerable practice before reliable results can be obtained. It is for use in hospitals and by pedi-

[1] Quoted by Holmes, Amer. Jour. Dis. Chil., vol. 12, i, July, 1916.

atrists who are seeing many cases of spasmophilia, or who are especially interested in the subject.

It is not practical for others to use, and it is quite possible to diagnose and to treat active spasmophilia successfully without it. Therefore, as I do not wish to bore the average reader by filling up space in the middle of a chapter with something that is of no practical value to him, I have discussed the electric reactions in an appendix at the end of the chapter.

Active Symptoms of Spasmophilia.—The most common active symptoms are:

1. Laryngismus stridulus.
2. Tetany.
3. General convulsions.

Spasm of the bronchial musculature ("bronchotetany") has also been observed.

Laryngismus Stridulus.—This is a frequent and characteristic manifestation of spasmophilia. It consists of a spasmodic contraction of the laryngeal muscles, and in the mildest cases is manifested merely by a crowing sound during inspiration, when the child is laughing or crying. In somewhat more severe cases there is a momentary cessation of respiration, accompanied by a slight degree of cyanosis, and followed by the characteristic "crow." In the most severe cases the symptoms may be extremely alarming. The attack of apnea comes suddenly, preceded by a short intake of the breath. Cyanosis is marked, the baby struggles for the breath it cannot get, and loses consciousness if the period of apnea lasts more than a few seconds. There may be also associated general convulsions. After a few seconds, in most cases, the spasm relaxes, the breath is drawn in with a crowing sound, and consciousness returns. In rare cases the spasm may be so severe that intubation or tracheotomy is necessary, and death has been reported.

Attacks of laryngismus stridulus may be very frequent, often as many as thirty or forty in the twenty-four hours.

Tetany or *carpopedal spasm* consists of a tonic contraction of the hands and feet. It may or may not be accompanied by

general convulsions. The position of the extremities is quite characteristic, the hands being flexed at the wrists, turned to the ulnar side, with the thumb drawn across the hand toward the little finger. The feet are extended on the legs, and the toes are tightly flexed.

There is usually evidence of considerable pain during the spasm, especially if one tries to unclinch the hands, and sometimes the backs of the hands and feet may be considerably swollen. There is usually no loss of consciousness during carpopedal spasm unless general convulsions occur along with it. The spasm ordinarily lasts from a few minutes to a few hours, but may continue for several days or even weeks. It occurs in by no means a large proportion of spasmophilic cases, but when it does occur is pathognomonic.

General Convulsions.—General convulsions represent one of the most common manifestations of spasmophilia, and may occur with laryngismus or tetany or, more commonly, alone. It is probably true that the majority of repeated convulsions occurring in infants under two years of age are manifestations of spasmophilia. Some exciting cause is usually necessary, such as the onset of an acute infectious disease, teething, indigestion, etc. There is nothing especially characteristic about spasmophilic convulsions, except that a great many may occur in the course of twenty-four hours, and that there is sometimes an associated tetany.

Bronchial Tetany.—This condition is probably more common than is generally realized.

It was first described by Lederer[1] in 1913, who gave it the name "bronchial tetany." Curschmann soon after described certain other cases of a somewhat different type from those of Lederer.[2] Short papers by Rietschel and by Wieland appeared in 1913 and 1914, but aside from this very little has been written regarding it. Lederer saw 58 cases of spasmophilia among 5903 ambulatory and 767 ward patients; 6 of these showed "bronchial

[1] Ztschr. f. Kinderheilk., 1913, Bd. 7, 51.
[2] Münch. Med. Woch., 1914, lxi, No. 6.

tetany." His patients were all under six months of age and all of them died. In most of his cases there was continued spasm of the bronchioles, probably lasting until death, and giving rise to pulmonary atelectasis, cough, cyanosis, and rapid respiration. According to Lederer the condition most likely to be confused with bronchial tetany in infancy is pneumonia. *x*-Ray of the chest is of the greatest value in diagnosis, and serves to differentiate the two conditions. The atelectasis is caused by tonic spasm of the bronchial smooth muscle, which shuts off the air-supply to the alveoli supplied by that particular bronchial tube.

Since the condition of spasm may last for days, weeks, or months, the air in the shut-off alveoli is absorbed, the walls collapse, and that portion of the lung becomes atelectatic. In Lederer's cases there was dulness over certain portions of the chest, which seemed sharply demarcated, while over the rest of the chest there was likely to be emphysema. The bronchial spasm may be continuous or intermittent, and in one case seen by us[1] the intermittent attacks of spasm somewhat resembled whooping-cough.

General Condition of Spasmophilic Infants.—The nutritional condition is never normal, although sometimes these children may appear fat, and may be of normal weight, or even above it. The flesh is not firm, however, nor is the color good. In most cases the baby is obviously undernourished and suffering from indigestion. The most common type of indigestion seen is probably chronic fat indigestion.

Diagnosis.—The diagnosis should not be difficult in most cases. The Chvostek sign is present in about three-quarters of all cases, and if present in children under two years of age is pathognomonic. According to Holmes[2] it is highly suggestive under four or five years, but may occur in mild degree in normal children of over three years.

The appearance of tetany is quite characteristic, and can hardly be confused with anything else.

[1] Med. Clin. North America, September, 1920.
[2] Loc. cit.

Laryngismus stridulus, likewise, is such a striking condition that it should not ordinarily be mistaken. The two conditions with which it might be confused are *congenital laryngeal stridor* and *breath holding* due to temper.

Congenital laryngeal stridor sounds a good deal like laryngismus stridulus to the inexperienced observer. It is probably caused by a congenital narrowing of the epiglottis,[1] and gives rise to a noisy inspiration sometimes, but by no means always, accompanied by crowing. The noisy inspiration is continuous, however, and not spasmodic, as it is in laryngismus stridulus, nor is it accompanied by cyanosis, loss of consciousness, or convulsions.

Breath holding is common in certain highly strung children. It is usually brought on by attacks of temper, when the child has been crossed in some way. He starts to cry vigorously, begins to get red in the face, then blue, and finally becomes limp and stops breathing for a moment, sometimes with a loss of consciousness, sometimes without. The period of apnea is only of short duration, and he soon "catches his breath." There is no crowing inspiration, no convulsion, and the attacks come on almost invariably following a display of "temper." These characteristics should easily serve to differentiate the two conditions.

It should practically always be possible to diagnose active spasmophilia without the use of the electric reactions. In latent cases and in certain active cases manifested by convulsions, but not by tetany or by laryngismus stridulus, when the Chvostek sign is negative, the determination of the electric reactions is necessary in order to make a certain diagnosis. These are, without doubt, the most reliable diagnostic criteria of spasmophilia, but, as we have said before, are not practical for average use (see Appendix).

Prognosis.—Spasmophilia is not without danger to life, as occasionally a child with largygismus stridulus or general convulsions may die. The prognosis as to cure should be good in

[1] Morse, Case Histories in Pediatrics, Boston, 1920.

the vast majority of cases, as there are fairly satisfactory methods of treatment.

It is possible, however, that considerable permanent damage may be done to the central nervous system, and some clinicians believe that spasmophilic children who have suffered from repeated convulsions are never quite normal mentally.

Treatment.—*Of the Active Manifestations.*—A spasmophilic convulsion is treated in much the same way as any other convulsion would be. A good sized dose of castor oil should be given, and the lower intestine emptied by an enema. It is likely that these things will have been done before the doctor arrives. The next thing to do is to relieve the convulsion.

This may be done in any one of three ways:

Chloral.—The rectal administration of chloral is probably the most generally satisfactory way of controlling convulsions. Even small infants bear it well, and it works quickly, usually in about twenty minutes. I always carry in my bag a solution of chloral hydrate containing 5 grains to the teaspoonful, and give it mixed with a little warm milk high into the rectum with a glass syringe and a small rectal tube. It is usually well retained if the buttocks are held together for fifteen minutes or so after administration. The dose is relatively large, partly on account of the method of administration, partly because large doses are needed to overcome the extreme nervous irritability which is present. An initial dose of 5 grains is usually not too much for a well-grown baby of seven months, and another dose half the size of the first should be repeated in half an hour if the first has not taken effect. Despite the fact that it is well borne by even young infants, chloral is not a drug that can be used carelessly, as it is sometimes very depressing to the circulation. I have seen the heart rate drop to 12 to the minute following a moderate sized dose of chloral to a baby of six months. The heart rate should, therefore, always be carefully watched, and camphor or brandy given if it is much lowered or shows signs of irregularity.

Ether or Chloroform.—The inhalation of a small amount of

ether or chloroform is a very efficient method of controlling convulsions, and works more quickly than does chloral. On account of the danger to the heart in infants from chloroform, and the possibility of starting up a respiratory irritation (particularly in rachitic children) with ether, my personal preference is for chloral.

Morphin.—Subcutaneous injections of morphin are likewise efficient, but I never like to use this drug in children under two years of age, as they are very susceptible to it, and doses which would not be considered at all large may cause poisoning.

Inasmuch as almost all children who have spasmophilia are under two years, it has not, in my opinion, a very wide application in this disease. It is, however, recommended by several good authorities.

Carpopedal spasm may often be relieved by a hot soak in the tub at about 110° F. If this does no good, chloral may be used in the same way that it is in general convulsions.

The subcutaneous injection of magnesium sulphate is said to be very efficient in controlling carpopedal spasm, although I cannot vouch for it from personal experience, having never had occasion to try it.

It was first used by Berend,[1] who injected 20 c.c. of an 8 per cent. solution into the subcutaneous tissue of the buttocks. It has since been used by a number of other students of spasmophilia with apparently good results, and no bad ones, save a moderate amount of discomfort at the site of the injection. One injection is usually enough to control the spasm, but it may be necessary to repeat it again the next day. Its effect is not of long duration, and its use applied only to the control of the active manifestations, and not to the correction of the underlying disorder of metabolism.

It is certainly worth a trial either in obstinate tetany or in general convulsions which do not respond to other methods of therapy.

Laryngismus Stridulus.—Slapping the baby on the back or

[1] Monatschr. K. finderheilk., Orig. 12, 1913–14.

throwing cold water in his face often relieves laryngismus stridulus. In severe cases it may be necessary to undress the baby and dip him alternately in warm and cold water, or in rare cases artificial respiration, tracheotomy, or intubation may need to be resorted to.

General Treatment of the Underlying Condition.—*The whey of cow's milk aggravates spasmophilia; breast milk cures it.*

For twenty-four to forty-eight hours after severe convulsions, tetany, or bad attacks of laryngismus no milk should be given, but the baby should be fed on a cereal gruel with sugar added if desired, but no salt. It is of the utmost importance to keep the bowels moving freely either by the use of castor oil or milk of magnesia, and it is also probably of some importance to promote a free diuresis. The fluid intake should, therefore, be pushed.

In the treatment of spasmophilia there is nothing to be compared to breast milk, and for the permanent feeding a wet-nurse should be secured if possible. The manifestations of spasmophilia are so terrifying to the parents that they are usually glad to do anything that promises relief, and a diet of breast milk almost always relieves the active manifestations. Sometimes it acts almost like a miracle, and I well remember one infant of seven months who had been having repeated convulsions for several weeks. He never had another after breast feeding was begun. It may be said that breast milk is almost a specific, and that there are but few cases in which a prevention of the occurrence of active symptoms cannot be expected.

If it is not possible to secure a wet-nurse, artificial feeding is carried on according to the general principles of infant feeding. It is important to correct any existing disturbance of digestion, and after this has been done the spasmophilic condition may change from the active to the latent type. It is very important not to feed a mixture rich in whey, as the sodium and possibly potassium salts of the whey tend to increase nerve irritability, and thus to aggravate the spasmophilia. A cream and precipitated casein mixture contains only small amounts of whey

salts, and may be of service for a while, although it might not be suitable for continued administration. The addition of cereal and of vegetables to the diet should be begun as early as possible; cereal at the sixth or seventh month, and vegetable purées at the eighth or ninth. The sodium content of the diet must be kept low, therefore meat soups, which contain considerable amounts of sodium salts, should not be used, and no salt should be added to any cereal or vegetable purée that is given.

The baby must not be allowed to be constipated, and it is well, for a while, to put a teaspoonful of milk of magnesia in the day's feeding as a routine.

Drugs.—Calcium therapy is of very definite value in most cases, as might be expected from the nature of the disease. Most students of spasmophilia who have had experience with this praise it highly, and it is probable that those who have not secured good results have used too small doses.

Marriott and Howland,[1] who are perhaps somewhat more enthusiastic on the subject than the majority of clinicians, say, "Calcium has a very prompt effect in preventing all the symptoms of active tetany, and if present they almost always disappear in thirty-six to forty-eight hours. The electric reactions also change, so that a cathodal opening contraction with a current of less than 5 milliamperes is no longer obtained. The calcium content of the serum also rises, but in most cases does not come quite back to normal. We know of hardly another drug which acts with the promptness and the regularity that calcium does in tetany."

Method of Administration.—Large and frequent doses are necessary in order to flood the system with calcium, and to keep it so flooded. Either calcium chlorid or calcium lactate may be used, the former usually being preferred on account of its greater calcium content. Calcium chlorid exists in two forms, the crystalline, which contains only about 18 per cent. of calcium, and the fused, or anhydrous, which contains 36 per cent. Calcium lactate contains about 13 per cent. As it is the calcium

[1] Loc. cit.

content of the drug in which we are chiefly interested, the anhydrous salt is what should be written for, and if the crystalline form of calcium chlorid or calcium lactate is used it is necessary to give twice as much in order to secure the same amount of calcium contained in half the amount of the anhydrous chlorid. Good results cannot be secured without large doses, and therefore from 10 to 15 grains of the anhydrous chlorid should be given four or five times a day to begin with, and may be reduced as the active symptoms of spasmophilia subside. It can be given in the milk, or its somewhat unpleasant taste is perhaps better disguised if it is given in orange juice.

℞. Calcium chlorid (anhydrous)... ʒix;
Water.....................ad. ℥vj.—M.
S.—One teaspoonful five times a day in milk or orange juice.

Calcium treatment should be continued for a considerable period until the tendency to spasmophilia has entirely disappeared. It is well usually to continue it until May or June (Howland and Marriott), but the dosage need not be always so large as at the beginning of treatment. If the chlorid upsets the stomach, the lactate may be used instead, but must be given in very large doses in order to secure results. Its taste is not unpleasant, it is readily soluble, and is best given in powdered form mixed with the baby's milk. About 120 grains a day should be given. According to Bachenheimer,[1] a heaping teaspoonful of powdered calcium lactate weighs about 75 grains; thus about 1½ teaspoonfuls divided between the different feedings would be the correct daily dose.

Cod-liver Oil and Phosphorus.—Inasmuch as rickets is so constantly associated with spasmophilia, cod-liver oil and phosphorus should be given, and it is possible that this may help not only the rickets but also the spasmophilia by causing an increased calcium retention.

The Electric Reactions.—The apparatus necessary consists of a battery, a milliamperemeter, a switch for reversing the

[1] Monatschr. f. Kinderheilk., Bd. 14, 1916.

polarity of the current, a rheostat for controlling its strength, and two terminal electrodes covered with absorbent cotton moistened in salt solution.

The inactive electrode is applied over the abdomen, the active over the peroneal nerve as it winds about the head of the fibula, on the outside of the leg. The current is then made or broken, first with the cathode and then the anode as the active electrode. According to Wilcox the test for cathodal closure should be made first, as response to this occurs most readily. Then the anodal closure, anodal opening, and cathodal opening should follow in order. It is best to begin the tests with a strength of current sufficient to produce a muscular response, and then to reduce it gradually to the point at which the response fails. According to Wilcox one hand should be kept over the foot, as it is often possible in this way to feel a slight twitch when it cannot be detected with the eye.

Response to the electric reactions varies considerably, according to the age of the child, and even from day to day in the same child, so it is not always possible to tell definitely what is normal and what is abnormal by any absolute standard.

According to Holmes, who has most thoroughly studied the electric reactions in normal and spasmophilic infants and children of various ages, the following is the correct interpretation:

Cathodal Opening.—A cathodal opening contraction with less than 5 ma. of current is pathognomonic of spasmophilia in children under five years of age.

Anodal Opening.—An anodal opening contraction appearing with a current less than that causing an anodal closing contraction, and less than 5 ma., is pathognomonic in almost all cases during the first six months of life. Its appearance with a current of less than 2 ma. is probably pathognomonic up to the fourth or fifth year.

Cathodal Closing.—The cathodal closing contraction is almost always obtained with a current of less than 5 ma. in normal children under six months, and after this time it is regularly

present with a current of less than 5 ma. It is, therefore, of no value in the diagnosis of spasmophilia.

Anodal closing contraction usually requires more than 5 ma. in infants less than six months old. From then up to two years the A. C. C. is frequently, and after two years regularly, obtained with a current of less than 5 ma. An anodal closing contraction with a current of less than 5 ma. is, therefore, suggestive in the first six months only.

The only two really important reactions are the cathodal opening and the anodal opening, and of these two, the former is the more important. As a summary it may be said that if the cathodal opening contraction occurs with less than 5 ma., or if the anodal opening is less than the anodal closing, and less than 5 ma., spasmophilia is present.

For a more complete discussion of the electric reactions, see the following references:

Holmes, Amer. Jour. Dis. Chil., vol. 12, 1, July, 1916.
Howland and Marriott, Quart. Jour. Med., 11, 289, 1918.
Wilcox, Amer. Jour. Dis. Chil., vol. 1, June, 1911.
Reye, Arch. Ped., 31, 1914.
von Meysenburg, Amer. Jour. Dis. Chil., vol. 21, 1921.

CHAPTER XIX

SCURVY[1]

INFANTILE scurvy is a disease of nutrition probably dependent upon the prolonged lack of some essential element in the diet. It is characterized especially by a weakened or inefficient condition of the endothelial lining of the blood-vessels, which predisposes to hemorrhage, especially under the periosteum of the long bones, into the skin and mucous membranes, and from the kidney. Barlow[2] in 1883 was the first to emphasize the fact that infantile scurvy is a distinct disease. Its occurrence had been noted long previously, but it was usually considered an acute manifestation of rickets. It occurs frequently in conjunction with this disease, but probably bears no relationship to it. It is the same disease as adult scurvy.

Occurrence.—Scurvy is not at all an uncommon disease, and is apparently on the increase. Its incidence in the Out-patient Department of the Children's Hospital, Boston, from 1904 to 1913 was found by Morse[3] to be as follows:

Year.	Percentage of scurvy cases.
1904	0.11
1905	0.43
1906	0.17
1907	0.33
1908	0.24
1909	0.24
1910	0.47
1911	0.61
1912	0.67
1913	0.87

[1] For the most exhaustive account of scurvy yet published in any language see Dr. Alfred F. Hess's fascinating monograph, "Scurvy, Past and Present," to which I shall often refer in this chapter.

[2] Abstr. Proc. Roy. Med. and Surg. Soc., London, n. s. 1, 102, 1883.

[3] Boston Med. and Surg. Jour., 1914, clxx, p. 504.

Glendenning,[1] in a study of the out-patient records for 1916–20 from the same hospital, found that the incidence for these five years averaged about 1 per cent., a considerable increase over Morse's figures.

This increase is probably due to the fact that more babies are being fed on heated milk than was formerly the case, and undoubtedly the disease is much more prevalent than even these figures show, as many latent or subacute cases pass unrecognized. It is not a disease of poverty or poor hygiene, and is as common in the well-to-do as in the poor—according to some authors, more so. It is a disease which can be prevented, and which should not occur at all if the baby is being fed intelligently. Season apparently has very little influence on its occurrence, nor has the previous nutritional state of the child. It is confined almost entirely to bottle-fed babies, but may occur exceptionally in the breast fed. It is most common in the second half of the first year, but occurs not infrequently in the first half of the second year, and rarely in older children. The youngest case in the American Pediatric Society's oft-quoted report (1898) was at three weeks; the youngest case seen by Hess was at 4½ months.[2] In none of Still's 54 cases was the age under five months.[3]

Etiology.—All experimental and clinical data indicate that scurvy is caused by the lack of some essential element in the diet rather than to the presence of some harmful element, to a faulty proportion of fat, carbohydrate or protein in the diet, or to other factors. At the present time the general opinion is that it is due to the lack of a specific vitamin, which has been called "water-soluble C" or the antiscorbutic vitamin. This view is supported by much evidence, both experimental and clinical. Our modern knowledge of this disease dates from 1912, when Holst and Fröhlich[4] produced it in guinea-pigs by limiting

[1] To be published.

[2] Scurvy, Past and Present (Hess).

[3] Brit. Med. Jour., July 28, 1906.

[4] Ztschr. f. Hygiene u. Infectionskrankheiten, 1912, vol. lxxii.

the diet to grain, and cured it quickly by the addition of fresh vegetables. Since then we have learned a great deal more about it, largely through the efforts of Hess and McCollum and their collaborators in this country. Scurvy in infants occurs especially with three sorts of food: proprietary foods, condensed milk, and heated milk, either boiled or pasteurized, all foods which are not "fresh," and in which the antiscorbutic vitamin is lacking. It is easily cured in many cases by simply substituting a diet of fresh raw milk for the previous food, or still more quickly and with more certainty if orange juice or a vegetable is added. It is probable that it is necessary for a baby to take a vitamin-poor diet over a considerable period of time before manifest scurvy develops, according to Hess about six months. Active scurvy represents, however, the end-result of a long-continued lack of the antiscorbutic vitamin in the diet, and probably long before this condition appears there is a state of poor nutrition present (of "latent" scurvy).

The antiscorbutic vitamin occurs in fruit juices, in vegetables, in germinated pulses and cereal grains, in meat (especially glandular organs), and in milk. It is the most sensitive and unstable of the three vitamins, and in milk especially is easily destroyed by heat, alkalinization, aging, drying, or oxidation. Its exact chemical composition is unknown, and it has not been isolated in a pure state.

Milk is rather poor in antiscorbutic vitamin, and considerable quantities must be taken in order to protect from scurvy, according to Hess, at least a pint daily. It is therefore possible for scurvy to develop on a diet of raw milk if not much is taken; 100 c.c. of fresh raw cow's milk is equal in antiscorbutic power to only about 3 c.c. of orange juice,[1] and as Hart, Steenbock, and Ellis[2] have shown, the vitamin content of the milk is directly proportional to the vitamin content of the cow's fodder. They found that summer pasture milk was much more potent as an antiscorbutic than dry feed milk or winter-produced milk,

[1] McCollum in Nelson's Loose Leaf Medicine.

[2] Jour. Biol. Chem., 1920, xlii, 383.

involving the ration of corn, ensilage, or sugar mangels. This, then, may be a factor in the production of scurvy. Although cow's milk is not rich in the antiscorbutic factor, it is not at all common to see scurvy in babies who have been taking raw milk. It is common, however, on a diet of boiled or pasteurized milk. It is possible, however, for babies to be fed on boiled milk for a long period of time without developing scurvy, and without the addition of an antiscorbutic, provided the milk is fresh to begin with and is used soon after being boiled. If boiled milk were the most important cause of scurvy, one would expect it to be very common in France and Germany, where all milk fed to infants is boiled as a routine. Such, is, however, not the case, and Hess[1] quotes Variot, who during twelve years distributed in his out-patient department 400,000 quarts of sterilized milk, heated in $\frac{1}{2}$-liter bottles and sealed at the farm, without ever having had a case of scurvy develop. According to Hess, other factors may be just as important as boiling, and prolonged heating at a lower temperature, as in pasteurization, may be more deleterious to the antiscorbutic vitamin than the higher temperature reached when milk is boiled for a few minutes. The freshness of the milk has a great deal to do with it, and Hess is of the opinion that the aging incident to pasteurization is fully as important as the heat in the destruction of the antiscorbutic power of the milk. Oxidation is another factor which he considers important, and in most of the methods of commercial pasteurization there is ample chance for this to take place.

Thus it may be said that stale[2] heated milk, whether boiled or pasteurized, predisposes to scurvy. It has also been shown that the antiscorbutic vitamin is especially sensitive to alkalinization. This may be of considerable practical importance if the baby is being fed on a food to which an alkali has been added, such as sodium citrate or potassium carbonate (malt

[1] Amer. Jour. Dis. Chil., November, 1917, vol. 14.

[2] This means merely milk which is not fresh; it does not mean sour or putrid milk.

soup). Faber[1] showed that potassium citrate even in a concentration of 0.25 per cent. was able to diminish or destroy the antiscorbutic power of cow's milk. Hess and Unger[2] have also found that milk to which alkali (potassium carbonate) has been added will not protect against scurvy as efficiently as does milk without the addition of an alkali, and that the antiscorbutic principle in orange juice is made inefficient by being rendered twentieth normal alkaline to phenolphthalein. Individual predisposition probably has something to do with the development of scurvy, and cases are on record where one of twins developed it, while the other, who was fed on exactly the same diet, did not. There is no good evidence to show that infection, indigestion, or constipation play any rôle in the etiology.

It may be said as a summary that infantile scurvy is caused by a lack of the antiscorbutic vitamin in the diet. This lack may be brought about by feeding proprietary foods or condensed milk, which are notably lacking in the vitamin, or by using too little raw milk in a weak milk modification, or by using milk in which the vitamin content has been lowered by boiling, pasteurization, aging, or alkalinization.

Although fully developed scurvy is a hemorrhagic disease, the clotting power of the blood is only slightly diminished, and even this is not constant.[3] The number of platelets is within normal limits. There is, however, always an anemia of the ordinary secondary type, which may occasionally be severe. The metabolism shows nothing of especial interest or importance.

Signs and Symptoms.—Scurvy should be regarded not as an essentially acute disease, but as a long-continued nutritional disturbance, which may exist for months before characteristic hemorrhagic symptoms develop.

Hess especially has insisted strongly upon this, and has called attention to what he calls "latent" and "subacute" scurvy.

[1] Proc. Soc. Exper. Biol. and Med., N. Y., 1919–20, xvii, p. 40.

[2] Jour. Amer. Med. Assoc., November 1, 1919, vol. 73.

[3] Hess and Fish, Amer. Jour. Dis. Chil., 1914, vol. 8, pp. 386–405.

The latent condition represents the earliest stage, and is difficult to recognize.

"When about six months of age the baby has ceased to thrive, to gain satisfactorily, to look strong, or to eat as we should desire. The most careful physical examination has failed to solve the difficulty. On the other hand, the history of a diet of heated milk and lack of antiscorbutic food, considered in conjunction with the pallor and lack of appetite, the increased knee-jerks, and perhaps the cardiorespiratory syndrome (increased pulse and respiration rate, see below) has awakened suspicion, and has led us to prescribe orange juice with a view to diagnosis as well as treatment. The result frequently has been magical."[1]

"Subacute" scurvy is somewhat more definite. The baby does not thrive, and fails to gain, or gains only a little, despite a diet which fulfils his caloric needs. He is irritable, has a poor appetite, and perhaps has slight edema of the eyelids. The papillæ at the tip of the tongue are congested and prominent, and there may be seen an occasional petechial spot over the body. There may be slight tenderness of the legs, especially to pressure, and the knee-jerks are markedly exaggerated. There is likely to be enlargement of the heart, especially to the right, which shows well by the *x*-ray, but which may be difficult to detect by percussion. The pulse and respiration are especially important, according to Hess. Both are considerably increased in rapidity, the respiration relatively more than the pulse, and there may be a rapid drop in both soon after orange juice is given. The urine may contain a few red blood-cells or albumin. The bones may show by the *x*-ray slight periosteal hemorrhages, or the "white line" of Fränkel (see below). Such a picture may go on for some time before active scurvy develops, and is usually not recognized.

Active Scurvy.—When the scorbutic process is well developed well-marked signs and symptoms occur. The usual story is that babies who have been fed on proprietary foods or heated milk, without the addition of orange juice, develop a marked tender-

[1] Jour. Amer. Med. Assoc., vol. lxviii, January 27, 1917 (quotation, Hess).

ness of the legs, and cry with pain every time they are moved. This is the most common symptom—often the only one—and is usually sufficient upon which to make a diagnosis of scurvy.

An interesting analysis of the first symptom noted by the mother was made from the records of 93 cases by Morse[1] in 1914 as follows:

First Symptom Noted

Crying on handling	69
Paresis	11
Swelling of legs	5
Abnormality of gums	2
Ecchymosis	1
Bloody urine	2
Failing	1
Condition discovered at hospital	2

Some of the most important signs and symptoms are the following, which, however, are not likely to occur all together in the same case:

General Symptoms.—The state of nutrition may be poor or good, according to what the child has been previously fed on. The average case does not, however, show evidences of severe malnutrition, but the flesh is always flabby and the color poor. The child is extremely fretful and irritable, and shrieks with pain every time he is moved. There is usually no associated gastro-intestinal disturbance, but there may be sometimes looseness of the bowels. The appetite is poor, a condition which does not usually come on suddenly with the other acute symptoms, but has been present for some time while the scurvy was developing. The temperature is more likely to be normal than elevated, but not uncommonly reaches 101° or 102° F. If it continues for any length of time after orange juice therapy has been started, there is probably some complicating infection present. Scorbutic babies are very susceptible to infection, and for this reason care should be taken, especially in a hospital ward, that they are not exposed to respiratory infection. Pyelitis is not an uncommon complication.

[1] Loc. cit.

There may be a "rosary" which is very similar to a rachitic rosary except that the beading is more angular. That this is a true manifestation of scurvy, and not caused by a complicating rickets, is shown by the fact that it rapidly disappears when orange juice is added to the diet (Hess).

The *legs* are practically always tender, usually exquisitely so, so that the slightest movement or pressure causes the most severe pain. The tenderness is caused by subperiosteal hemorrhage, which occurs most commonly in the lower portion of the femora (Fig. 25). There may be no swelling apparent if the hemorrhage is not extensive, but if it is extensive there may be a great deal of swelling, noted especially on the front of the thighs or

Fig. 26.—Characteristic position of the legs in scurvy. Note also exophthalmos.

lower legs. This may feel very hard if the hemorrhage is of long standing and has begun to organize, and there are cases on record where an operation has been performed, mistaking the swelling for a bony tumor. If the tenderness is well marked, motion is so painful that there is likely to be a pseudoparalysis, and the baby lies in a characteristic position, with the legs everted (Fig. 26). It is very rare for hemorrhage to occur within the capsule of a joint, but there may be hemorrhage into the loose tissue about the joint. The tenderness is, however, almost always of the *shaft* of the bone and not of the joint. Fractures at the lower third of the femur or tibia are not uncommon, and there may be separation of an epiphysis. Sub-

Fig. 25.—Infantile scurvy. Section of femur showing subperiosteal hemorrhages with periosteal bone formation. There are hemorrhages in the bone-marrow and distortion of the line of ossification at the lower end. (MacCallum.)

periosteal hemorrhage may also occur in the bones of the arm, but is not at all common.

Hemorrhage in Other Localities.—The Skin.—Petechial hemorrhages into the skin and mucous membranes are common, and should always be carefully looked for, as they are often of great value in diagnosis. They are most common on the hard palate, on the upper part of the back and neck, on the chest, and more often on the upper than on the lower extremities (Hess and Fish). I recall one case a few years ago in which the tenderness of the legs was only very slight, and the suggested diagnosis was confirmed by a few small petechial spots hidden behind the ear, the only other physical sign present. In some cases the hemorrhages in the skin may be more extensive, and resemble the large "black-and-blue" spots so often seen in purpura.

The Gums.—A spongy, hemorrhagic condition of the gums is common, and is a valuable diagnostic sign. This is seen usually only when teeth are present, and is most likely to occur about the central upper incisors. There is a turgid, purplish swelling of the mucous membrane of the gum about the teeth, which is rather soft and tender, and which bleeds easily. It is almost always present in well-developed scurvy if the teeth have come through, but in a few cases it may be lacking when well-marked signs of scurvy are present in other localities. In some cases the hemorrhagic condition of the gums may be evidenced only by a thin red line or a small patch behind the tooth, and may be easily overlooked (Still[1]). In severe, long-standing cases the gum condition may be serious, and extensive ulceration and slough may be present. While it is not common to observe disturbance of the gum if no teeth are present, it may be seen in some cases if the teeth have come down so far that they are near the surface of the gum.

The Urine.—Blood in the urine is not at all uncommon, and in a few cases may be the first symptom noted. Any baby during the second half-year showing this symptom should always be suspected of having scurvy, until it is proved to be due to

[1] Brit. Med. Jour., July 28, 1906.

other causes. Occasionally the blood is visible macroscopically, so that the urine is colored bright red, but far more often it is normal in appearance macroscopically, and a few red cells are seen under the microscope. The urine is also likely to be considerably diminished in quantity during the acute stage,

Fig. 27.—Exophthalmos with edema and extravasation of blood into the eyelids.

and a marked diuresis may be seen after the administration of orange juice as the child improves.

Exophthalmos.—Hemorrhage under the periosteum of the orbital plate of the frontal bone occurs occasionally, giving rise to exophthalmos. This usually comes on suddenly, and is one of the most striking rare manifestations of scurvy. It may be unilateral or bilateral, most commonly the former, and may

be of such a degree that the eye literally bulges from the head. The eyelids are usually more separated than normal on account of the eyeball which bulges between them, but if there is a good deal of extravasation of blood and edema of the lids the eye may be closed, as is shown in Fig. 27. There may be sometimes merely a swollen discolored condition of the lids without exophthalmos. The exophthalmos of scurvy comes on much more suddenly than any other form of exophthalmos, which should serve to differentiate it from other conditions; also it is in most cases easily cured by the addition of orange juice to the diet, and in a few days the eye resumes its normal position.

The Digestive Tract.—Hemorrhage from the digestive tract is not common, but small amounts of blood may occur in the stools.

The Circulatory System.—As Hess has pointed out, the heart is almost always enlarged, especially to the right. This may sometimes be detected by percussion, but is more accurately determined by *x*-ray examination. The blood practically always shows a secondary anemia, which may be of severe degree. This is probably very slow in its development, and one of the characteristic things about "latent" scurvy is the pallor. The blood-vessels are weakened, allowing extravasations of blood, which accounts for the hemorrhage. In order to demonstrate this Hess and Fish[1] devised the "capillary resistance test." An ordinary blood-pressure arm band is attached to the arm. The pressure is raised to 90 and is held there three minutes. The band is then removed, and when the cyanosis has faded, examination is made for petechial spots below the constriction. They found that most scurvy cases showed many petechiæ, and normal subjects did not. Normals may, however, show a few petechiæ just below the pressure band which are of no significance. The pulse and respiration are increased sometimes to a considerable degree, and the increased pulse particularly may persist for a considerable period after the baby has been appar-

[1] Loc. cit.

ently cured of scurvy. The respiration is increased relatively more than the pulse, and instead of the normal 1 : 4 ratio, the ratio may be 1 : 3 or 1 : 2 (Hess).

Diagnosis.—The diagnosis of well-developed scurvy is not at all difficult if one is familiar with the disease. The chances are that any baby from the age of six to eighteen months has scurvy who begins suddenly to have pain in the legs and to cry when handled. If, added to this, some of the other signs of scurvy are present, such as spongy gums, petechial hemorrhages into the skin, or blood in the urine, the diagnosis is unmistakable. Despite its characteristic symptomatology, scurvy is a disease which is often overlooked or wrongly diagnosed simply because the practitioner is not familiar with it. In 37 cases seen by Morse[1] in consultation, from 1909 to 1914, the disease was recognized by the attending physician but four times. The most frequent diagnoses made were rheumatism, acute nephritis, and poliomyelitis. Syphilitic epiphysitis and osteomyelitis are two other diseases not infrequently mistaken for scurvy.

The differential diagnosis between scurvy and these five conditions is not difficult in most cases.

Rheumatism.—Babies very seldom have rheumatism. It occurs most commonly between the age of four and twelve years. The youngest case I have myself seen was at two years. Furthermore, in rheumatism the tenderness is about the joint and not in the shaft of the bone, as it is in scurvy. The temperature would be more likely to be elevated in rheumatism, and the other signs of scurvy would not be present. Despite the fact that rheumatism practically never occurs in small babies, this is the mistake most commonly made in the diagnosis of scurvy.

Syphilitic Epiphysitis.—This condition almost always occurs before the age of five months, scurvy rarely does. Furthermore, the trouble is about the epiphysis and not in the shaft of the bone, as it is in scurvy, and practically always other signs of syphilis are present. If the diagnosis is in doubt, the Wasser-

[1] Loc. cit.

mann test, x-ray, and therapeutic test should easily serve to differentiate the two conditions.

Osteomyelitis is not common in babies of the age who would have scurvy. The septic appearance of the baby, high temperature, leukocytosis, absence of other signs of scurvy, and the x-ray should make confusion unlikely.

Poliomyelitis.—This disease is not infrequently confused with scurvy. In poliomyelitis there is not, however, the extreme tenderness seen in the former disease, the knee-jerks are absent, and in the acute stage there is usually a high fever. If in scurvy there were sufficient periosteal hemorrhage to cause pseudoparalysis, enough to confuse the condition with poliomyelitis, there would almost certainly be some swelling of the leg and other signs of scurvy present elsewhere. If there is still doubt, lumbar puncture or x-ray should clear it up.

Acute Nephritis.—If a baby has blood in the urine, with other symptoms of scurvy also, there is no danger of confusing scurvy with acute nephritis. If, however, the only definite sign consists of a little albumin and a few red blood-cells in the urine microscopically, the differential diagnosis may not be easy. There are certain points of differentiation, however. In the first place, if a small baby has acute nephritis, he usually is fairly sick with it, and has considerable albumin in the urine, with many casts and red cells in the sediment. Edema would probably also be present, and there would probably be also a history of some previous infection to account for the nephritis. The history of the previous diet of the baby is of considerable importance: if he has been receiving an adequate amount of fresh raw milk, with as much as a tablespoonful of orange juice a day, he certainly is not suffering from scurvy. If he has been on a scurvy-producing diet, and has gradually been failing, is pale, and has a poor appetite, the chances are that he has scurvy. If after these considerations it is impossible to decide, the therapeutic test (2 tablespoonfuls of orange juice a day) will make the diagnosis in a few days.

The x-Ray Diagnosis.—The x-ray is often valuable in giving

confirmatory evidence for the diagnosis of scurvy. The outline of the epiphysis is quite distinct in contradistinction to its appearance in rickets, and this alone should serve to distinguish the two conditions (Lovett). There may be considerable bone atrophy, which is uniform along the whole shaft of the bone.

There is likely to be at the end of the diaphysis the so-called "white line" of Fränkel, which was formerly thought to be diagnostic of scurvy. It may also occur in rickets, however. It is due to an increased density of bone at the end of the di-

Fig. 28.—Well-marked "white line." Arrow indicates slight elevation of the periosteum.

aphysis. The "white line" may be seen early in the disease, sometimes before any evidence of periosteal hemorrhage is visible, and is likely also to persist for a considerable period after the clinical symptoms have subsided. It is, therefore, of some diagnostic value in early cases, provided rickets can be ruled out. The most characteristic feature seen in the x-ray appearance of the bones in scurvy is the hemorrhage. In mild cases this may be manifested simply by a little thickening or bulging of the periosteum, or in more severe cases by most extensive irregular

shadows indicating blood-clot which has involved the soft tissues (Figs. 29, 30).

Fig. 29.—Separation of epiphysis of femur, also large blood-clot.

Prophylaxis.—The prophylaxis of scurvy is of the utmost importance, and, what is more, is successful. If a baby is properly fed, scurvy should not occur.

In spite of the fact that boiled and pasteurized milk pre-

dispose to scurvy, this does not outweigh the great advantage obtained from their relative freedom from bacteria, and it is easy enough to give an antiscorbutic. Every baby taking pasteurized or boiled milk should be started on orange juice

Fig. 30.—Large blood-clots of both femur and tibia

as soon as he is three months old, and it is probably not possible for any baby who is taking daily an adequate amount of this most potent antiscorbutic to develop the disease. What constitutes an adequate amount is not certain, but probably

2 tablespoonfuls a day is enough, and this is the quantity that it is best to use. I have recently seen a number of cases of scurvy where the mother said that she had been giving the baby orange juice, but on closer questioning it was found that the baby did not like it very well, so perhaps only as much as a teaspoonful three or four times a week had been taken. I have never seen a case where as much as a tablespoonful has been given every day. Babies usually take orange juice readily. It is best given about one hour before the feeding, twice daily, in doses of 1 tablespoonful at a time. It may be diluted or sweetened with cane-sugar, if the baby takes it more readily in this way, and if it causes "sour stomach" with regurgitation, which it may do occasionally, it may be diluted with a little lime-water just before administration. In a very few babies orange juice causes looseness of the bowels, but these are very few and far between, and, as a matter of fact, orange juice does not deserve at all the reputation it has as a laxative; in most cases it is entirely without action on the bowels. In the rare cases where orange juice is not well borne, canned tomato juice or potato soup can be used (see below). Green vegetables, such as spinach or carrots, have but little place in the prophylaxis of scurvy in infants, as their antiscorbutic power is low, and it would be necessary to take relatively large amounts in order to secure any effect.

Is it necessary to give orange juice to babies who are taking raw milk? It probably is not necessary in the vast majority of cases, provided an adequate amount of milk is taken, but in view of the fact that even raw milk may vary a great deal in its antiscorbutic power, it is well to give orange juice to every baby as a routine. It is common, when a barley- or oat-water diluent is being used in the milk formula, for the mother to add boiling hot diluent to the milk; then it stands for a considerable period of time, slowly cooling, and although I have no idea what the temperature of such a mixture would be, I have seen several cases of scurvy when the milk was not boiled or pasteurized, where this seemed to be important as a causative factor.

Treatment and Prognosis.—There is no therapeutic procedure in medicine where more striking and rapid results are obtained. If a boiled or pasteurized formula has been used, this should be discontinued and a raw formula of the same strength substituted, or if a proprietary food has been the previous diet, the baby should be put at once on a suitable raw milk modification. In many cases this would suffice to cure the condition, but results are so much more brilliant and rapid if orange juice is added that one would not try to treat scurvy without it. An ounce a day is sufficient, given half in the morning, half in the afternoon, an hour before the feeding. In practically all cases the acute symptoms will be much improved in forty-eight hours, and at the end of about four days should have practically subsided. Results are so certain that, if improvement does not take place, there should be considerable doubt that the baby has scurvy. Although the acute symptoms subside rapidly, the bone changes, the anemia, and the rapid heart action may persist for some weeks, and it may be some time before the baby is in first-class condition. In addition to the orange juice it is well to give 3 grains of the saccharated oxid of iron three times a day in order to aid in the correction of the anemia. It is needless to say that the baby should be handled as little as possible while his legs are tender, and that small doses of paregoric should be given to make him comfortable, if necessary. The prognosis is almost always good, provided the condition has not progressed too far. If no treatment is given, the baby slowly wastes away and dies from weakness and malnutrition. In long-standing, exceptionally severe cases, even orange juice may be unavailing, and Holt records 4 deaths out of 100 cases. In the extreme type of case, where the stomach may be so irritable that orange juice cannot be retained, it may be given intravenously, apparently with good results. The orange juice is boiled five minutes, is made neutral or slightly alkaline by means of N/1 NaOH just before administration, and 10 c.c. is given intravenously each day for several days (Hess).

Antiscorbutic Foods.—The antiscorbutic vitamin exists in all

fruit and vegetable juices, germinated cereal grains and pulses, in glandular animal tissues, such as liver, kidney and pancreas, and in milk. Non-germinated cereal grains contain no antiscorbutic factor, and muscle tissue contains so little as to be negligible.

Orange, Lemon, and Lime Juice.—Orange and lemon juice are the most powerful antiscorbutics known. Lime juice is not nearly so powerful. Orange juice can be dried, preserved in the form of a powder, and it retains its antiscorbutic power. It can also be boiled and still remain potent, but if stored in the cold for three to six months it becomes inactive. Alkalinization for twenty-four hours likewise renders it non-potent; 3 c.c. of orange juice equal in antiscorbutic power about 100 c.c. of milk. The juice of orange peel is also markedly antiscorbutic.

Tomato Juice.—Next to orange juice, tomato juice is an efficient practical antiscorbutic. Hess has used it extensively in an infant asylum, and has found it very satisfactory. He gives 2 tablespoonfuls of the juice from canned tomatoes daily to babies of over two months, and has noticed no ill effects from much larger doses. If oranges cannot be obtained, this is probably the best antiscorbutic to use.

Potato.—Although adults depend largely upon potatoes as an antiscorbutic, they are not at all rich in the antiscorbutic principle, and it is necessary to take so much in order to secure an effect that potato is not at all important as a therapeutic agent for infantile scurvy provided orange, lemon, or tomato juice can be obtained. If these are unobtainable, potato-water should be used. One tablespoonful of mashed potato (the outer mealy layer from a boiled potato) is shaken in a pint of water in which the potatoes have been boiled, and the resulting gruel is used as a diluent for the milk modification.[1]

Carrots, grapes, apples, and bananas have only slight antiscorbutic power. As a general thing the leafy vegetables have more potency than the roots and the tubers, and young vegetables more than old. Cabbage is the most potent of all the vegetables.

[1] McCollum and Ruhräh, loc. cit.

CHAPTER XX

THE TREATMENT OF ECZEMA IN INFANCY

Eczema is a very common condition during the first year of life, and often has a good deal to do with the feeding; hence its inclusion here. It may be divided into two broad types, the wet, or exudative, occurring usually in otherwise healthy, overfed babies, most commonly breast fed, or the dry type, which is more likely to occur in undernourished babies. It is not likely to start before the first month, and often shows a tendency to disappear spontaneously after the first year, although it may persist for years in many cases. The exact processes which go on in the body to produce eczema are not known, but it is certain that three factors are often operative:

1. Local irritation.

2. Overfeeding with fat or sugar, or in some cases with starch.

3. Anaphylactic idiosyncrasy to foreign protein (most commonly lactalbumin, casein, egg-white, or beef).

The therapy in the present state of our knowledge is based upon these three etiologic factors.

No good results can be obtained if the greatest attention to detail is not observed, and if the patient is not seen often. In severe cases the child should be seen every day. *With painstaking, intelligent treatment there is no case of eczema in infancy that cannot be greatly helped, and most cases can be cured entirely.*

In my opinion local treatment is of paramount importance, and the reason for most failures is that it is not carried out correctly. It should be used, however, in conjunction with the other two measures.

Local Treatment.—The essential thing to remember is that in any given case of eczema the condition may differ widely on various parts of the body, and that, therefore, it may be neces-

sary to use several different preparations at the same time for local application. For instance, what is suitable for a seborrheic scalp, is not at all suitable for an oozing eczema of the cheek or for a cracked eczema of the popliteal space. In most cases that one sees there usually are different types or stages of eczema on different parts of the body, and it is necessary, therefore, to know what sorts of application are suitable for each type. At the first visit I very frequently give the mother as many as three or four different preparations and teach her the name and special purpose of each, so that she will know, as she goes along from day to day, which one to use, according to the particular stage that the eczema happens to be in. This is of considerable importance, and it is of great value to teach the mother to recognize a seborrhea, a dry scaling, or a weeping eczema, and to know which preparation to use for each type.

In a general way the following are the types or stages of eczema that are seen, sometimes all in the same patient:

1. Wet.
2. Dry, very red, and acutely inflamed.
3. Dry and rough, not acutely inflamed.
4. Seborrheic.
5. Intertriginous.
6. Diffuse papular or vesicular.
7. Infected.

Wet, oozing eczema is most likely to be seen in fat, overfed babies. It occurs especially on the cheeks, behind the ears, and in the popliteal and antecubital spaces. It begins usually as small, red, acutely inflamed papules, which soon coalesce, and finally begin to exude serum. Crusts may form, and underneath the crusts the skin is raw and oozing. If in a locality where there are folds of skin, as in the popliteal space, large bleeding cracks may develop.

Crude coal-tar is so successful in curing this type of eczema that it works in practically every case. There is nothing else that can approach it in efficiency, and since its introduction a few years ago the treatment of infantile eczema has been revo-

lutionized, and where it used to take weeks of constant struggle to effect any improvement in a weeping eczema, it may now be controlled in most cases in a few days. Crude coal-tar is not the same thing as the ordinary wood tar of the Pharmacopeia, which has been so long used in the treatment of skin affections, and has nothing whatever to do with it. It is a by-product in the manufacture of coal-gas, and cannot be obtained from most retail druggists, but may be secured from many of the large drug houses, who get it from the coal distilleries. Different "lots" of crude coal-tar vary considerably, as there is no standardization of the product, and not infrequently one may get a shipment of tar which is not good. A good crude coal-tar should be of an inky black color and of a very thick consistency, so that it will barely run out of a bottle. It should be perfectly smooth and should contain no granules whatever. This is the preparation to use in every moist case of eczema, except where there is infection or on the scalp. It is not used where there is infection, as it may make it worse, and it is not suitable for use on the scalp, because it makes a sticky mess with the hair.

Method of Use.—The crude tar is painted over the raw surface twice a day by means of a cotton swab on the end of a throat stick. After it dries, which usually takes only a few minutes, a dusting-powder may be applied, but is not necessary. The skin is painted in this way morning and night until the oozing has been stopped, which rarely takes over two or three days. It should not be removed with olive oil, vaselin, or anything else, but should be allowed to wear off gradually, which does not take long. When it has worn off, a rather smooth, red, and tender new skin is seen underneath, which is very easily irritated if rubbed or scratched. At this stage a bland protecting ointment is used, such as either one of the following:

℞.	Bismuth subcarbonate	ʒij;
	Lime-water	q. s.
	Anhydrous lanolin . . . . ad.	℥ij.—M.

℞.	Starch, Zinc oxid . . . . āā	ʒij;
	Vaselin . . . . ad.	℥ij.—M.

Tar contains a certain amount of phenol, and there is a possible danger of toxic absorption if it is used on a large area of broken skin. In the ordinary case of eczema this does not, however, have to be considered, and I have never seen any ill results from its use.

Dry, Red, Acutely Inflamed Eczema.—This type of eczema is perhaps the most common, and is likely to be seen on almost any part of the body. It may occur in small red papules of varying sizes, or in large patches, with sharply defined edges, or in diffuse irregular areas. Tar is also very efficient here, but is best used in the form of a paste. It should be applied twice a day, or if on an exposed place such as the face, where it is easily rubbed off by the baby, frequently enough so that there will always be present a fairly thick coating of the paste:

℞.	Crude coal-tar		ʒj;
	Zinc oxid Starch }	āā	ʒij;
	Vaselin	ad.	℥ij.—M.

This paste is rather thick and of a blackish-brown color. It is very dirty, of course, and therefore old clothes should be used, or if the eczema is in a locality where bandages can be applied, these should be used. The best cloth as a bandage for eczema is old linen or cotton, which has been scorched in the oven. Scorched cloth is much less irritating to the skin than unscorched, and sometimes such a small detail as this may make a good deal of difference.

If there is considerable induration or scaling of the skin, and the eczema is of long standing, the addition of 10 grains of salicylic acid to the ounce of ointment is of value.

Dry, Rough, Not Acutely Inflamed Eczema.—For this type of eczema tar is not usually necessary, and it is possible to employ something that is less dirty.

For very mild cases, where the skin is simply a little rough and dry, either plain lanolin or bismuth ointment are the best preparations.

℞.	Bismuth subcarbonate........	ʒij;
	Lime-water..................	q. s.;
	Anhydrous lanolin.........ad	℥ij.—M.

It is important to remember when using any ointment not to simply give directions to apply it two or three times a day, *but to apply it often enough so that the irritated surface will be continually covered by the salve, no matter how often it has to be applied.*

If there is a good deal of roughening and thickening of the skin, the following is better:

℞.	Salicylic acid.................	gr. xx;
	Zinc oxid, Starch ....āā	ʒij;
	Vaselin...................ad.	℥ij.—M.

Seborrheic Eczema.—This type of eczema, usually occurring on the scalp, is very common in small babies, and may be present when there is none on any other part of the body. It is usually called "cradle cap." It consists of many greasy scales and crusts. The best preparation to use on the scalp in most cases is ordinary boric ointment. This is applied very thickly, with a good deal of rubbing, twice a day, and then a turban made from an old handkerchief or towel is fitted to the head and kept there. Or with small babies it is usually simpler to have the mother get a few cheap cotton bonnets, and use these instead, as they fit better. It is very important to use a large amount of salve, to rub it in well, and to prevent it from being rubbed off by the use of a cap or turban. The boric ointment is applied every day, and no attempt made to remove it until the fourth day, when a gentle shampoo with castile soap is given, during which it will usually be possible to remove most of the seborrheic material. After this the boric ointment applications are continued as before, with a shampoo twice a week. When the seborrhea is considerably better, and most of the scales have been removed, it is often well to shift to a salve containing

resorcin, which is often very efficient in finishing the cure, and in preventing the seborrhea from recurring:

℞. Resorcin .... gr. xx;
Vaselin .... ad. ℥ij.—M.

For scalps with only a mild seborrhea or a dry scaling condition a daily gentle rubbing with olive oil and shampoo three times a week usually is efficient, and keeps the skin in good condition.

Intertriginous Eczema.—This type of eczema is usually seen on the inner side of the thighs, about the genitalia, symphysis pubis, and often extends up the abdomen as far as the umbilicus. It consists of an intense fiery redness, occasionally with considerable thickening, but with little scaling. It is not ordinarily moist, except as it occurs in very fat babies where two opposing skin surfaces come together, at the neck, under the armpits, etc. The fiery red, intensely irritated condition occurring on the inner side of the thighs and on the lower part of the abdomen is often rather difficult to treat, as it is impossible to keep it dry and to prevent irritation by urine and feces. It is probably caused in the beginning by irritation from urine, especially if it be strongly acid. The first essential in treatment is to prevent irritation in so far as possible. In order to accomplish this no diapers are to be used on the baby, and the lower part of his body is to be kept exposed to the air most of the time in a reasonably warm room. A thick pad of absorbent cotton is put between the legs to absorb urine when passed, and a diaper underneath to receive the stool. The cotton and diaper should, of course, be immediately changed as soon as they are dirtied. If the urine is strongly acid, enough potassium citrate is given in each feeding to make it slightly alkaline; 10 grains usually suffices. Local applications are not so efficient as in some of the other forms of eczema. The best one to begin with is "whitewash":

℞. Zinc oxid .... ℥j;
Lime-water .... ad. ℥vj.—M.

This is shaken vigorously, and applied every hour in liberal amounts, on soft scorched old cotton or linen cloths.

If "whitewash" is unavailing, bismuth ointment or tar paste is used. In using a salve with this type of eczema it is better to spread it thick on pieces of soft scorched linen or cotton cloth, and then to apply these to the parts. If the irritated area can be kept reasonably free from urine and feces cure should be fairly rapid; if not, it may take a long time. Between skin surfaces, such as the axilla, folds of the neck and groin, this type of eczema, or intertrigo, is likely to be moist, and the treatment is somewhat different. The irritated areas should be cleansed once daily with warm lime-water, or a weak sodium bicarbonate solution, dried carefully, and liberally sprinkled with a dusting-powder, such as zinc stearate. It is of the greatest importance to prevent the two skin surfaces from coming together, and for this purpose small pledgets of absorbent cotton sprinkled with the dusting-powder are used.

Diffuse Papular or Vesicular Eczema.—This occurs more frequently in children over eighteen months of age than in small babies. It comes on acutely, and is characterized by innumerable small vesicles or papules which are distributed evenly over the whole surface of the body, particularly the trunk. It is best treated by starch baths and tar paste. A rather thin solution of starch is made in the same way that one would prepare it for laundry purposes. In the morning the child is stripped and bathed all over with the starch solution, sopping it on gently. It is allowed to dry on. In the evening tar paste is applied and rubbed well into the skin with the flat of the hand, not using it quite so thickly as would be the case with a facial eczema.

Infected Eczema.—If secondary pyogenic infection is present, as is not infrequently the case, this must be cleared up before improvement can take place.

If the infection is diffuse, with a good deal of septic oozing and crusting, there is nothing so efficient as a 10 per cent. ointment of ammoniated mercury in vaselin. This should be used

frequently enough so that a thick coating of it will be over the infected areas all the time. If the infection is in the form of a few boils, which are especially likely to occur on the scalp, their contents are expressed and a 20 per cent. solution of silver nitrate applied to the cavity of the boil and to the skin in the immediate vicinity. Tar, or any thick paste, should never be used until all infection has subsided.

If the reader will remember the following ten preparations, which have all been mentioned above, but are repeated in table form for the sake of clearness, and will learn how and when to use them, he will need no other local applications in the treatment of infantile eczema:

1. Crude coal-tar.
2. Tar paste: Crude coal-tar, ʒij;
Zinc oxid, Starch, āā ʒij;
Vaselin, ad. ℥ij.
3. Lanolin.
4. Boric ointment.
5. 20 per cent. silver nitrate solution.
6. 10 per cent. ammoniated mercury in vaselin.
7. Starch paste: Zinc oxid, Starch, āā ʒij;
Vaselin, ad. ℥ij.
Or the same, with gr. xx of salicylic acid added.
8. Bismuth ointment: Bismuth subcarbonate, ʒij;
Lime-water, q. s.;
Anhydrous lanolin, ad. ℥ij.
9. Resorcin ointment: Resorcin, gr. xx;
Vaselin, ad. ℥ij.
10. "Whitewash": Zinc oxid, ʒij;
Lime-water, ad. ℥vj.

Prevention of Scratching.—If the child is continually scratching there is no chance for the eczema to heal, and one night of scratching may undo the good results of a week of treatment. There are two good methods of preventing this. By the use of

cuffs about 8 inches long of stiff cardboard, covered with cloth, which fit tightly over the elbows, and by preventing any flexion at the elbow, prevent scratching of the face. Cuffs do not, however, prevent scratching of other parts of the body, and it is always advisable in a bad case to use aluminum mittens as well. These are hollow cylinders of thin aluminum, which fit over the hands and fasten to the sleeve of the night dress. For all bad cases of facial eczema a mask with small holes for the eyes, mouth, and nose should be used. This is cut from old cotton or linen cloth, and should be kept on continuously while the eczema is acute. Mothers, as a rule, are very inefficient in handling eczema until they have had a considerable amount of instruction, and it is therefore essential to go over all details with them with a good deal of care at the first visit, and to see the child frequently in order to be sure that they are carried out. It is always a good plan to have a well-trained children's nurse for a while at the start of a bad case, and I cannot impress too strongly upon the reader that eczema in infants is a condition where it is vital to pay careful attention to the smallest details in order to secure good results.

Water is ordinarily irritating to the skin in most cases of eczema, and baths should not, therefore, be employed. The genitalia and buttocks may be cleansed with absorbent cotton and water; during the acute stages it is best to let the rest of the body alone. If caking of any paste used has taken place, or if crusting is excessive, it may be softened and removed with a little lanolin or vaselin. In general, it is best, however, to let any applications that have been made gradually wear off, rather than to remove them.

When the eczematous condition is much improved baths may be given, and it is well with all infants who have a tendency to eczema to make the water less irritating by using bran or oatmeal. A cup of bran or oatmeal is put into a small cheesecloth bag and stirred about in the bath water for a few minutes, so that it becomes milky. A superfatted lanolin soap should be used, which is much less irritating to the skin than ordinary

soaps, and it is well with all babies who have a tendency to eczema to give a lanolin rub every day after the bath.

If the face has a tendency to dryness or chapping after the acute stages of the eczema have been controlled, bismuth paste should be applied each time the baby goes out of doors, and especial care should be taken that the face is not exposed to cold, blustering winds.

The Feeding.—Most babies with eczema are well nourished, indeed, it is the very fat, overfed breast baby who is most likely to have it, and improvement cannot usually be expected until the food is reduced in quantity or quality. It is always well to secure a specimen of the breast milk for analysis if the baby is breast fed, and in a large proportion of cases the fat will be found too high, often from 4 to 6 per cent. The sugar may be also at fault, but its percentage in breast milk ordinarily varies but little. It is probable, when sugar is at fault, that the trouble is caused rather by too much food than too high a sugar percentage. The stools are likely to be rather oily, and usually show a large excess of fat under the microscope. In order to reduce the amount of food the feeding intervals are lengthened from three to four hours, nursing is permitted for only about eight minutes, and about 2 ounces of water or barley-water is given either before or after the breast feeding. The mother should be made to exercise, and should omit fats, potatoes, bread, desserts, and candy from her diet for a while. In this way it is often possible to considerably reduce the fat content of her milk. If all this is unavailing, there is some temptacion to wean the baby, but in most cases this is not advisable, as it is by no means certain that the eczema will improve on a diet of cow's milk. In certain cases, however, weaning *does* cure the eczema, as I had brought out a few weeks ago. A large, overfed breast baby of three months began to lose his appetite and to have eczema on the face, arms, and scalp. There was a large amount of breast milk which showed 5.5 per cent. of fat. The mother was made to exercise, her diet was reduced, and the baby was given water before feedings—all to no avail. The eczema could be kept

under control by the use of local applications, but it was never possible to get rid of it entirely. The baby was finally weaned at the urgent request of the mother and was fed on a simple milk modification low in fat. In a very few days his eczema disappeared entirely without the use of local applications, and has never returned. If any food element is at fault when a baby fed on cow's milk has eczema it is most likely to be the fat, or more rarely the sugar. If fat is at fault, there may or may not be evidences of fat indigestion; if sugar is to blame, loose acid stools are usually present. If the baby is a fat, strong baby, in a good state of nutrition, feeding for a time on a fat-free or low fat food is desirable. He will probably lose some weight, but it will do him no harm, and his eczema is very likely to improve considerably. If the baby is not well nourished it is not advisable to reduce the fat in the food unless he is grossly overfed with fat, unless there are evidences of considerable fat indigestion, or the eczema is an unusually severe one. In most cases, however, the undernourished baby does not have a severe eczema, of the raw weeping type, and it is important for him to gain weight and to secure a better nutritional condition. Therefore the food should not be reduced, and it is possible to keep the eczema within reasonable limits by local treatment. As a matter of fact, in a good many of these undernourished babies with a dry, reddened, but not exudative eczema the condition shows a tendency to disappear as soon as the nutrition becomes better. In children over a year old, who are on a mixed diet, overfeeding with starch is not an uncommon cause of eczema, and the stools should be examined carefully to see if any evidences of starch fermentation are present. In this type of case there will usually be three or four mushy, foul stools a day, containing a large amount of undigested starch and cellulose. There is occasionally a chronic infection of the intestinal contents with the gas bacillus in these cases, which plays a part in the indigestion, and hence in the eczema. Such a child should be fed on a low fat and low starch diet, with lactic acid milk as its basis.

For some years Dr. C. J. White, Professor of Dermatology in the Harvard Medical School, has been sending me the stools of his eczema patients for examination, and, without quoting any exact figures, I should say that over half certainly showed some abnormality of digestion, either fat, starch, or abnormal fermentation. It is always worth while to carefully investigate the condition of the digestive tract in any case of eczema. Sometimes indigestion seems not to be a factor, and changing the diet has no beneficial effects on the eczema; in other cases the results are brilliant.

Idiosyncrasy to Food Proteins.—In some cases of eczema there is an anaphylactic idiosyncrasy to food proteins, the most common ones being the lactalbumin or casein of human or cow's milk, egg-white, or occasionally egg yolk, and the protein of beef. This idiosyncrasy seems to be the cause of the eczema, for when the offending protein is removed from the diet the eczema is improved or cured in most cases.

It is, therefore, well worth while to endeavor to determine, in any case of eczema, especially with children on a mixed diet, whether any such idiosyncrasy exists, and while I do not agree with those who believe that most cases of eczema are due to anaphylactic idiosyncrasy, I still have seen enough cases where this was undoubtedly a factor to consider that the anaphylactic food tests constitute one weapon, at any rate, by which we may attack the disease. These tests are performed as follows:

Small linear scratches about ½ inch long are made with a needle on the skin of the back, deeply enough to penetrate well into the skin, but not enough to draw blood. Then a small amount of the dried protein[1] of the various foods to be tested is put on the scratch, a drop of 1/10 normal (0.4 per cent.) sodium hydrate added, and rubbed into the scratch with the protein powder. One scratch is left as a control, and has sodium hydrate added to it, but no protein. If any protein gives a positive test, in about fifteen minutes (less in many cases), an urticarial wheal at the site of the inoculation develops, which

[1] Proteins are furnished by the Arlington Chemical Co., Yonkers, N. Y.

is surrounded by an area of erythema. Usually a positive reaction will give a wheal at least 0.50 cm. in diameter, but it is better to read the tests rather by their relation to the other scratches and to the control than by any standard size. If one wheal is considerably bigger than the reaction caused about any of the other scratches it should be called positive, even if it is not quite 0.50 cm. in diameter. Or if one scratch shows a large area of erythema without any wheal, and the other scratches show none, the test showing the erythema may be called positive. On very sensitive skins sometimes all the scratches will develop wheals of fair size, so it is rather in relation to the other scratches that we must interpret results than by any set standard. Dr. Joseph Grover and I have done some thousands of skin tests in the last two years on children with eczema and asthma, and we cannot help but feel that a great deal of caution is needed in interpreting these tests, and that, in general, those who have used them have been too eager to report positive reactions. If in a young breast-fed baby the test should be positive to one of the proteins of human milk, the baby should *not* be weaned, but the eczema should be treated locally, and the amount of milk taken by the baby somewhat reduced, in accordance with the directions given in the last section.

If in a bottle-fed baby casein or lactalbumin gives a positive test, the amount of protein in the formula should be reduced to as low a point as is consistent with the baby's nutritional needs, and supplementary feeding of solid food begun as early as possible. If the idiosyncrasy is very marked it may be advisable to use goat's milk. If the eczema is in a very bad condition, temporary improvement may sometimes be secured by feeding the baby on a cereal and sugar diet for a few days, without any milk protein. This cannot, of course, be kept up for any length of time. We have seen comparatively few reactions to the proteins of milk, and in our experience beef and egg protein are the most common offenders. These last two are, of course, easily removed from the diet. In doing skin tests on breast-fed babies it is not infrequent to find that a positive test may be

obtained to some food (egg, cow's milk, beef) which the baby has never eaten. In these cases, according to O'Keefe,[1] the sensitization has occurred through the breast milk, and if the foods which have given positive tests are omitted from the diet of the mother great improvement of the baby's eczema may take place. This is certainly worth taking into consideration in the treatment of eczema in the breast fed.

[1] Boston Med. and Surg. Jour., vol. 185, August 18, 1921.

CHAPTER XXI

PYLORIC STENOSIS AND SPASM

Pyloric stenosis, or to give it its full name, "congenital hypertrophic stenosis of the pylorus," consists of an hypertrophy of the circular muscle-fibers of the pylorus, giving rise to obstruction, with consequent projectile vomiting, rapid loss of weight, and final death from starvation if not relieved.

Occurrence.—It is not an uncommon condition, but not much attention was paid to it until a comparatively few years ago. Martin, in Osler's "System of Medicine" (1908), says that "there are now more than 150 cases recorded in the literature." From 1914 to 1920 Downes, of New York, himself operated on 217 cases.[1] These figures show how much more commonly it is now recognized than was formerly the case.

For some unknown reason it occurs more frequently in males than in females, the ratio being about 4 : 1. It is seen more frequently in breast-fed than in artificially fed babies, the probable reason for this being that the majority of babies are fed on the breast during the first few weeks of life, after which period the symptoms of pyloric stenosis rarely make their appearance.

Etiology.—The pyloric hypertrophy is undoubtedly congenital in origin, and a pyloric tumor has been observed in a seven months fetus (Dent) and in a number of infants a day or two old upon whom autopsies were performed. Its causation is obscure. According to Strauss[2] it is caused by rhythmic contractions of the pylorus during fetal life, which start at that time due to some abnormal stimulation of the nerves of the stomach. The condition of hypertrophy, he believes, progresses during

[1] Jour. Amer. Med. Assoc., vol. 15, No. 4, July 24, 1920.

[2] Ibid., vol. 71, No. 10, September 7, 1918.

fetal life, but becomes greatly increased after birth, owing to the additional irritation produced by food. Wall,[1] on the other hand, as do most other observers, believes that it is a simple developmental anomaly, and that any spasm which is present is secondary to the hypertrophy. He does not believe that "any muscular contraction would be able to produce such a large, hard mass of tissue" as the hypertrophied mass of muscle seen in these cases.

Pathology.—The circular, smooth muscle-fibers of the pylorus are hypertrophied, giving rise to an oval, hard, cartilaginous-like tumor, usually about the size of a small ripe olive. On section, the tissue of this tumor is whitish, porky, and non-vascular. The hypertrophy of the muscle-fibers causes narrowing of the pyloric orifice, and hence obstruction. This narrowing produces an infolding of the mucous membrane into rugæ, and the opening at the pylorus in severe cases may be so small that it will admit only a fine probe.

The walls of the stomach proximal to the pylorus are considerably thickened, and the stomach itself is usually dilated. The intestine in cases of average duration is small and collapsed, owing to the fact that it has received little food.

Symptoms.—The important signs and symptoms are:

1. Persistent projectile vomiting.
2. Progressive loss of weight.
3. Constipation.
4. Visible gastric peristalsis.
5. Palpable tumor.

The obstruction may be complete or partial, the severity of the symptoms depending upon the extent of the obstruction. The baby is born apparently in good health, and does well for the first week or two, when he suddenly begins to vomit without apparent cause. The vomiting rarely begins before the end of the first week or after the sixth. At first there may be nothing especially characteristic about it, but it soon becomes explosive, and food may be forcibly ejected for a distance of a foot or two.

[1] Arch. Ped., vol. 36, 1919.

The vomitus shows no particular evidences of indigestion. The vomiting may occur immediately after feeding or in between feedings, and is usually constant, but not infrequently several feedings a day may be retained, in which case the next time the baby vomits the vomitus is larger than the amount of the previous feeding. This is quite characteristic. The appetite is usually voracious, and these babies are almost always continually hungry, and will take large amounts of whatever is offered them.

In cases with almost complete obstruction severe constipation is the rule; the stools are infrequent, very small, and may contain but little fecal material. They not infrequently somewhat resemble meconium.

Loss of weight is very rapid and large, and not infrequently as much as one-third of the body weight will be lost. With changes in food temporary improvement for a few days is likely to occur, but is not permanent. If untreated, the baby dies in a few weeks from starvation.

Visible gastric peristalsis is an important sign and is present in practically all cases. It is best elicited by giving the baby an ounce or so of water, waiting a few minutes, and then gently scratching the skin over the stomach with a throat stick, when waves of peristalsis may be easily seen following each other from left to right across the abdomen. These waves in some cases may be as large as a small egg.

The stomach is in most cases considerably dilated, and the dilatation is easily visible, giving rise to an undue prominence of the upper portion of the abdomen.

Palpable Tumor.—Usually under the right conditions the pyloric tumor may be felt through the abdominal wall, most commonly slightly to the right and a little above the umbilicus, but occasionally high up under the edge of the liver. It takes a good deal of practice to feel a pyloric tumor on account of its relatively small size and on account of the fact that it is sometimes difficult to secure sufficient relaxation of the abdominal wall. When it is felt it is a diagnostic sign of the greatest im-

portance. The absence of a palpable tumor does not, however, rule out pyloric stenosis. The tumor is best felt when the stomach is empty and when there is no gaseous dilatation of the

Fig. 31.—Visible gastric peristalsis.

stomach or intestines, and cannot be felt when the baby is crying, with consequent spasm of the abdominal muscles. In

Fig. 32.—Visible gastric peristalsis.

order to get rid of gas a small catheter may be passed into the stomach, and in order to secure relaxation of the abdominal wall a little water is given to the baby in a bottle while feeling

for the tumor. If these conditions are present it may be felt, by experienced observers, in most cases.

(The diagnosis, prognosis, and treatment of pyloric stenosis and pyloric spasm will be considered together.)

Pyloric spasm consists of a spasm of the pyloric muscle, giving rise to much the same symptoms seen in pyloric stenosis, but to a lesser degree. The line between the clinical appearance of the two conditions is often not sharply defined, as in pyloric stenosis there is almost always some complicating spasm, and in pyloric spasm there may be enough hypertrophy of the circular muscle-fibers or the redundant mucous membrane to give rise to a palpable tumor.

Some authorities believe that there are not two separate conditions, but that all cases should be grouped under the head of pyloric stenosis, and considered under two groups, those with complete and those with partial obstruction. The weight of opinion, however, is that there are two separate conditions. This is borne out by the fact that in one group of cases the tumor at the pylorus is hard, non-vascular, and cartilaginous in character, while in the other group there may be no tumor at all, or if one is present it is soft and vascular, quite different from the tumor of true pyloric stenosis. The etiology of pyloric spasm is obscure; it may occur either in breast- or bottle-fed babies, but is more common in the latter. It is commonly seen in children of neurotic families, and besides the spasm of the pylorus there may be a hypertonicity of the voluntary muscles of the body as well, so that the baby holds his arms and legs very stiffly. This has been especially emphasized by Haas,[1] and since reading his paper I have noticed it in a number of cases. It is probably not far from correct to regard pyloric spasm as a result of gastric indigestion in a nervous baby.

Symptoms of Pyloric Spasm.—We are dealing here with a functional, partial occlusion. The symptoms resemble those of true pyloric stenosis, but are not so marked. The baby is likely to be of a fussy, irritable type, easily frightened by noises and

[1] Arch. Ped., vol. 36, 1919.

disturbed by handling. On the other hand, I have seen pyloric spasm in a baby who never cried and who always slept all night and a good part of the day. The vomiting is more intermittent, not so explosive, and the stomach is usually little if any dilated. It is not common for more food to be vomited than has been taken at the preceding feeding. Temporary improvement for a day or two is very likely to occur after a change in the food, the same as it does in pyloric stenosis.

There may be a moderate degree of constipation, but never to the extent that is seen in pyloric stenosis, and the stools are always fecal. They are often green and undigested and may contain mucus. Visible peristalsis is more frequently seen than not, but may be absent. In a few cases a tumor may be felt, but this is the exception rather than the rule.

Loss of weight is not so marked as in true pyloric stenosis, as a not inconsiderable amount of food reaches the intestines. Stationary weight or slight gains may be the rule, but if the condition persists, considerable loss may occur, and the baby may ultimately reach a severe degree of malnutrition.

Diagnosis.—Pyloric stenosis and spasm are differentiated from simple indigestion with vomiting in that in the latter condition the vomiting stops when the food is regulated, and the evidences of obstruction, such as explosive vomiting, palpable tumor, etc., are not present. Visible peristalsis may be seen in rare cases. The Roentgen ray shows but little interference with the emptying time of the stomach.

The diagnosis of pyloric stenosis when the obstruction is nearly complete is not difficult. The characteristic history, with explosive vomiting, small infrequent bowel movements, and marked loss of weight; the physical examination, with visible peristalsis and palpable tumor, form a picture which is definite and clear cut. A palpable tumor, is, however, not pathognomonic of stenosis, as it may be present in spasm when there is comparatively little obstruction. The chief difficulty is in determining the extent of the obstruction, which is essential in order to decide upon the method of treatment to be

Fig. 33.—Immediately after eating.

Fig. 34.—One-half hour after.

Fig. 35.—One hour after.

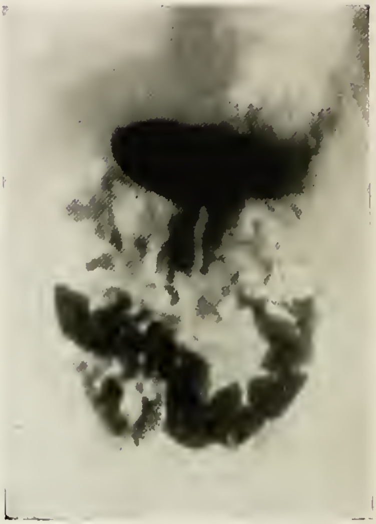

Fig. 36.—Three hours after.

Figs. 33 to 36.—Pyloric spasm, showing somewhat delayed emptying time, but by no means complete obstruction.

Fig. 37.—Immediately after eating.

Fig. 38.—One-half hour after.

Fig. 39.—One hour after.

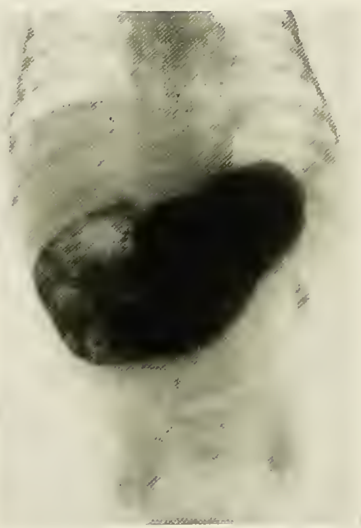

Fig. 40.—$2\frac{1}{4}$ hours after.[1]

Figs. 37 to 40.—Pyloric stenosis, showing almost complete obstruction.

[1] Not from the same case as Figs. 37–39.

employed. The Roentgen ray, taken in conjunction with the clinical findings, is here of great value, and although it has been said by some that this method of diagnosis is of comparatively little value, in my opinion it is invaluable, and gives us more accurate and valuable data as to the extent of the obstruction and the advisability of operation than do any of the other procedures which have been used for the same purpose, such as the passage of duodenal catheters or aspiration of the stomach contents. A feeding of about 2 ounces of a weak milk modification containing about a teaspoonful of bismuth subcarbonate is given by gavage, and plates are taken immediately afterward, in one-half hour, one hour, two hours, and four hours. In many cases it is not necessary to take the last plate, as the first ones may give enough data on which to base conclusions. There is no need of taking plates later than four hours after the bismuth meal, although this is sometimes done as a matter of interest. The first plate, in a normal series, would show that a small amount of bismuth has come through, the second and third should show that a considerable amount has passed the pyloric orifice, the fourth, that most of the bismuth has gone through, while the last plate should show the stomach nearly empty.

In pyloric stenosis with marked obstruction the first two plates usually show that no bismuth at all has left the stomach, the third and fourth, that most of it is still retained.

With partial obstruction, the picture is different according to the amount of obstruction present. In most cases of partial obstruction, whether due to true stenosis of mild degree or to spasm, half or more than half of the bismuth is likely to have left the stomach at the end of four hours. In cases of simple indigestion the emptying time may be somewhat delayed, but most of the bismuth will have left the stomach at the end of four hours.

In pyloric spasm the baby is more likely to be bottle fed than breast fed. The evidences of obstruction are not nearly so marked as in stenosis—the stools always contain considerable

fecal material—a tumor is not likely to be felt, and if it is felt it is smaller, especially longer and thinner (Morse) than the tumor in pyloric stenosis, and may sometimes be felt to contract beneath the finger. The loss of weight is usually not excessive, and there may be even a slight but unsteady gain. Visible peristalsis may or may not be present; it is practically always present in stenosis. The Roentgen ray shows some interference with the emptying time of the stomach, but it is never so marked as in true pyloric stenosis with nearly complete obstruction.

Treatment of cases with extensive obstruction, where there is marked loss of weight, visible peristalsis, palpable tumor, and a large amount of the bismuth meal remains in the stomach at the end of four hours (true pyloric stenosis).

Although not a few competent observers have reported good results in this type of case with medical treatment, the consensus of opinion is in favor of operation. In my opinion true pyloric stenosis is a surgical disease, and operation should be done as soon as the diagnosis is made. It is of very great importance to operate when the baby is in good condition, and although there is a possibility that he may improve under medical treatment, the chances are against it, and much valuable time may be lost. Surgical intervention, as performed now, carries with it a comparatively low mortality, and is far ahead of medical treatment of any sort. It is probable that many of the cases of so-called pyloric stenosis that have recovered under medical treatment have, in reality, been cases of spasm. The operation usually performed up to about six years ago was a posterior gastro-enterostomy. This was a rather long, serious operation, and the mortality was high.

The operation used now almost exclusively is the so-called Fredet-Rammstedt operation, or modifications of it, which consists simply in splitting the hypertrophied circular muscle-fibers of the pylorus down to the mucous membrane. This allows the mucous membrane to bulge out into the wound and overcomes the stenosis. The cure is permanent, and

although the tumor may persist for a considerable time after the operation, the stenosis does not. The operation carries with it comparatively little shock, and a skilled operator can do it in twelve or fifteen minutes.

The postoperative management is of great importance, and may mean all the difference between the life and death of the baby. It is especially important before operation to remove from the stomach any gas, mucus, and especially bismuth which may be still retained after the bismuth meal. I have only recently seen a case where the baby nearly died because he had a stomach full of bismuth which was not removed by gavage before operation. After operation it is well in much emaciated cases to give a subcutaneous infusion of normal saline (about 150 c.c.). Stimulation with adrenalin, caffein, or brandy may also be necessary.

Feeding is begun an hour or two after the baby comes out of ether, and it is of very great importance to secure breast milk if possible. About a dram of this may be given at first, diluted with an equal amount of water. For a few feedings it is given every hour. In the next few days the amount at each feeding, the strength, and the interval between feedings are increased, so that at the end of about two days an ounce at a feeding of nearly undiluted breast milk would be taken. It must be remembered that the intestine is in a collapsed condition and is not ready to receive much food; therefore the feeding in the first few days must be very cautious. At the end of about a week the baby can be put to the breast. If artificial feeding has to be used, whey is the best thing to begin with. In the course of a day or two fat is added to this in the form of 16 per cent. cream, so that the baby would at first get 0.50 per cent. fat, then 1 per cent., and finally, after about ten days, 2.50 or 3 per cent. As improvement continues and the baby becomes stronger the split protein feedings are discontinued, and a return to ordinary milk modifications is gradually made.

Prognosis.—The prognosis depends very largely upon the general condition of the baby and upon how long the symptoms

have been present. It is always doubtful in cases of long standing; it should be uniformly good if operation is done within a week or two after vomiting has started. The case from which the Roentgen-ray plates were taken was operated on only three days after the beginning of vomiting.

In 100 consecutive cases at the Babies' Hospital, New York, in which the vomiting had lasted less than four weeks, the mortality was only 8.7 per cent.[1] In those cases which had vomited more than four weeks it was 50 per cent. Kerley[2] states that the mortality in infants who have not vomited for more than two weeks should not be over 5 per cent.

In 78 consecutive pyloroplasties at the Children's Hospital, Boston, done by various members of the surgical staff, the mortality was 7.6 per cent.[3]

Porter[4] reports 26 cases, all except 2 of which recovered. In Downes' large series of 217 cases[5] there were 30 deaths, giving a mortality of 17.1 per cent. Almost all the babies who died had been vomiting for a long time and were in poor condition at the time of operation.

Treatment of Pylorospasm or of Pyloric Stenosis with Comparatively Slight Obstruction.—Treatment depends rather upon the extent of the obstruction than whether the condition is one of spasm or stenosis. Few cases of pylorospasm come to operation.

It is always a question of nice judgment to determine whether or not cases with incomplete obstruction need operation. If loss of weight is not great, or if the baby has been holding his weight, if the stools are fecal, and fairly large and frequent, and particularly if the Roentgen-ray plates show that obstruction is relatively slight (about three-quarters of the bismuth meal having left the stomach at the end of four hours), it is advisable to try medical treatment. If after ten days or two weeks the vomiting is no better and the baby is losing weight, operation

[1] Holt (Discussion), Trans. Amer. Ped. Soc., vol. xxx, 1918.

[2] Ibid.

[3] Ladd: Surg. Clin. North America, vol. No. 3, June, 1921.

[4] Arch. Ped., vol. xxxvi, No. 7, 1919.

[5] Jour. Amer. Med. Assoc., July 24, 1920.

should be resorted to. *Rapid loss of weight is the most important point in favor of operation*, and if progress down hill is steady and rapid, operation must not be delayed, as it is of the utmost importance to do it before the baby is in very bad nutritional condition.

Medical treatment may be discussed under three headings: feeding, stomach washing, and drugs, of which the first is the most important.

Feeding.—In either type of case, whether spasm or stenosis, it is worth while to try feeding with breast milk, provided the baby is not already on the breast. If he is already on the breast and vomits, or if breast milk is unobtainable, the thick cereal feeding, first advocated by Sauer,[1] is the most successful method.

His original formula was as follows:

Skimmed milk	9 ounces;
Water	12 ounces;
Farina	6 tablespoonfuls;
Dextrimaltose	3 tablespoonfuls

This is boiled one hour in a covered double boiler, and contains about 15 per cent. of cereal. It must be of a thick consistency, so that it will barely run off a spoon. From 2 to 8 tablespoonfuls, according to the size of the baby, are given every three hours.

Since Sauer's original paper it has been found that somewhat thinner mixtures work better, and the amount of farina now ordinarily employed is 1 tablespoonful to 5 ounces of liquid.

Porter[2] recommends using rice flour in the proportion of 1 tablespoonful to 7 ounces of liquid, and believes that this works better than farina, especially if farina causes a tendency to diarrhea, which it may do occasionally.

The mixture is so thick that it cannot ordinarily be taken from a bottle. It is usually given on the end of a throat stick, then the cereal is pushed into the back of the mouth with another throat stick. Or, as Dr. Griffith, of Philadelphia, suggests,[3] it

[1] Arch. Ped., July, 1918. [2] Trans. Amer. Ped. Soc., 1921.
[3] Ibid.

may be given through a large-holed Hygiea nipple by pushing it through with a spoon, while the nipple is in the baby's mouth.

It is not necessary to adhere strictly to any set formula in using the thick cereal principle; it is merely necessary to use small amounts of a concentrated, rather thick mixture, containing large amounts of starch, which is so thick and adhesive that it is vomited with difficulty. Whole or skimmed milk may be used in various proportions, according to the exigencies of the case, and sugar may or may not be added.

It must be remembered that these mixtures contain a large amount of starch, and that although the vomiting may stop, an intestinal indigestion due to excess of starch may arise. It is well, therefore, to examine the stools for starch under the microscope occasionally, and to cut down the amount fed if much undigested starch is coming through. It is always necessary to give water between feedings in order to cover the baby's fluid needs.

This is probably the most successful method of feeding this group of cases, and good results have been reported by almost all those who have used it. Personally, I have had comparatively little experience with it, but have secured good results in the few cases where it has been used.

Another way of feeding, especially in pylorospasm, is with dried milk containing a low fat (Dryco). This often works surprisingly well. It is usually best to begin with one-half strength, 4 level tablespoonfuls of dried milk to 8 ounces of water, and to gradually increase until full or nearly full strength is reached. Occasionally it is advantageous to combine a barley or farina gruel (about 3 per cent.) with the dried milk mixture.

Whey is often of value as a temporary food, and mixtures of gravity cream and whey have long been used. These are, as a rule, not very satisfactory, as in order to supply sufficient caloric value for weight increase it is necessary to use a fairly high fat percentage which is directly contraindicated in feeding any baby with an irritable stomach.

Stomach washing may sometimes be of value. A 1 per cent.

solution of sodium bicarbonate at blood heat is used. The washing is best done about one-half hour before feeding once or twice a day.

Stomach washing has the great disadvatage that it disturbs the baby a good deal. It is worth a trial, however.

Atropin.—Inasmuch as the pathologic condition in pylorospasm consists of a spasm of smooth muscle, and as most cases of pyloric stenosis are complicated by spasm, the administration of atropin would seem to be theoretically indicated. This has been used for a long time, with not very enthusiastic reports, until that of Haas[1] in 1919, who believes that excellent results can be secured with larger doses without danger to the baby. He recommends a 1 : 1000 solution of atropin sulphate, containing about $\frac{1}{1000}$ grain to the drop. A drop of this is put into each feeding, or is given in water if the baby is breast fed. If this is well borne, 2 drops are used at the next feeding, and so on, until at the end of twenty-four hours the dose may be 3 or 4 drops with each feeding. If the dosage used does not produce beneficial results, and if there are no symptoms of atropin-poisoning, the dose is increased to 5 or 6 drops with each feeding. It may be necessary to keep up the treatment for several weeks or even months.

Atropin treatment should always be tried. I have myself, however, never seen any very striking results from it.

Prognosis.—Most cases of pylorospasm recover with careful medical treatment. It is, however, a most annoying condition, and progress is likely to be slow. The institution of thick cereal feeding has done more to help us than anything else.

Not a few cases of mild pyloric stenosis likewise recover under medical treatment. There is always the suspicion that these may be cases of spasm and not of true pyloric stenosis. If after ten days or so of medical treatment loss of weight continues, and the vomiting is no better, operation should be resorted to at once.

[1] Arch. Ped., vol. 36, 1919.

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